

San Jacinto River Waste Pits Superfund Site

Site Information Package for National Remedy Review Board



**UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION 6
April 2014**

Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

SITE SUMMARY

The San Jacinto River Waste Pits Superfund Site (Site) is located on the western side of the San Jacinto River north and south of I-10 in Harris County, Texas.

The Superfund Site Identification Number (SSID) is 06ZQ. The Operable Unit (OU) is 00 (Sitewide). The Comprehensive Environmental Response, Compensation, and Liability information System (CERCLIS) Identification Number is TXN000606611.

The Site encompasses several impoundments, built in the mid-1960s for disposal of paper mill wastes, and surrounding in-water and upland areas as shown in [Figure 1-1](#). The northern part of the Site consists of a set of impoundments approximately 14 acres in size, and the surrounding sediment and soil areas. The northern impoundments are located on a partially submerged 20-acre parcel of real estate on the western bank of the San Jacinto River.

The Site is located in the estuarine portion of the lower San Jacinto River where the river begins to transition from a fluvial system to a deltaic plain. Ground surface elevations at the impoundments north of I-10 are less than 10 feet above mean sea level (MSL) ([Figure XX](#)). Ground surface elevations at the south impoundment area south of I-10 reach to nearly 13 feet above MSL ([Figure 3-1](#)). Two elevated features or mounds are apparent in the northeastern extremity and center of the southern impoundment area.

Tropical weather systems can have tremendous impacts on regional precipitation and hydrology along the Gulf Coast. Hurricane season runs from June 1 to November 30. Between 1851 and 2004, 25 hurricanes have made landfall along the north Texas Gulf Coast, seven of which were major (Category 3 to 5) storms. Tropical Storm Allison, which hit the Texas Gulf Coast on June 5 through 9, 2001, resulted in 5-day and 24-hour rainfall totals of 20 and 13 inches, respectively, in the Houston area, resulting in significant flooding. More recently, Hurricane Rita made landfall on September 23, 2005, between Sabine Pass, Texas, and Johnsons Bayou, Louisiana, as a Category 3 storm with winds at 115 mph and it continued on through parts of southeast Texas. The storm surge caused extensive damage along the Louisiana and extreme southeastern Texas coasts. On September 13, 2008, the eye of Hurricane Ike made landfall at the east end of Galveston Island and travelled north up Galveston Bay, along the east side of Houston. Ike made its landfall as a strong Category 2 hurricane, with Category 5-equivalent storm surge, and hurricane-force winds that extended 120 miles from the storm's center.

Flow rates in the San Jacinto River in the vicinity of the Site are partially controlled by the Lake Houston dam, which is located about 16 river miles upstream of the northern impoundments. The average flow in the river is 2,200 cubic feet per second (cfs). The river in the vicinity of the Site is affected by diurnal tides, with a typical tidal range of about 2 feet. Floods in the river occur primarily during tropical storms (e.g., hurricanes) or intense thunder storms. Extreme flood events have flow rates of 200,000 cfs or greater. Floods can cause water surface elevations to increase by 10 to 20 feet or more (relative to average flow conditions).

Between October 14 and October 21, 1994, heavy rainfall occurred in a 38-county area of southeast Texas. The San Jacinto river basin received 15 to 20 inches of rain during this week-long period, and had a peak discharge of 360,000 cfs, which is a return period greater than 100

years. The San Jacinto River stage height during the October 1994 flood had a maximum value of 27 feet at the Sheldon, Texas streamflow station, located north of the Site. Another storm occurring in 1940 had a river stage height of 31.50 feet at the same Sheldon location.

The 1994 flooding caused major soil erosion and created water channels outside of the San Jacinto River bed. This flooding caused eight pipelines to rupture and 29 others were undermined at river crossings and in new channels created in the flood plain outside of the San Jacinto River boundaries. The largest new channel was cut through the Banana Bend oxbow just west of the Rio Villa Park subdivision. This new channel was about 510-feet wide and 15-feet deep. A second major channel cut through Banana Bend just north of the channel through the oxbow. Both of these new channels were cut through areas where sand mining had been done before. Sonar tests in a 130-foot section south of the I-10 bridge located adjacent to the Site found about 10 to 12-feet of erosion from the bottom of the river bed.

The U.S. Department of Transportation undertook a nationwide riverbed erosion risk assessment study using a potential scour depth model in an effort to identify pipelines with a higher probability of failure due to natural disasters. The study provided an indicator of scour potential rather than an estimate of absolute scour depths. The study defined an “erosion hazard” from 0 to 100. Areas with the highest rank in scour depth and the highest rank in annual chance of flooding have an erosion hazard of 100. The study found that the erosion hazard for the area around the Site ranges between 95 and 100.

Salinity in the vicinity of the Site generally ranges between 10 and 20 parts per thousand (ppt) during low to moderate flow conditions in the river. During floods, salinity values will approach freshwater conditions.

The land use types in the area surrounding the Site are shown in Figure 2-1. Current land use surrounding Site includes mixed residential and industrial uses to the west, and undeveloped or residential areas to the east and north of the Site. Moving farther out from the Site, the amount of residential land use increases. Generally, development is more intense near the San Jacinto River and Houston Ship Channel (HSC) in areas located to the south. The San Jacinto River has many points of public access and supports fishing activities.

The former impoundments were built in the mid-1960s for disposal of paper mill wastes barged from the Champion Paper Inc. paper mill in Pasadena, Texas. The northern impoundments are believed to have been used for waste disposal from September 1965 to May 5, 1966. The paper mill waste was unloaded into the northern impoundments for stabilization and disposal. The excess water collected in the impoundment located to the east of the central berm was pumped back into barges to be taken to another location. An additional impoundment was constructed south of I-10, on the peninsula of land directly south of the northern impoundments, and also was used as a disposal area in the mid-1960s for paper mill waste similar to impoundments north of I-10. The southern impoundment was approximately 15 to 20 acres in size. The area south of I-10 is part of a peninsula on which significant industrial activity has occurred since at least the early 1960s. In contrast with the area to the north of I-10, the peninsula south of I-10 contains active operations of several shipping and marine industrial services businesses, with the area serving as a transport hub and as a location for barge or ship maintenance, cleaning and painting.

Physical changes in the 1970s and 1980s, including regional subsidence of land in the area due to large scale groundwater extraction and sand mining within the river and marsh to the west of the northern impoundments, resulted in partial submergence of the impoundments north of I-10 and exposure of the contents of the impoundments to surface waters. In addition, dredging by third parties occurred in the vicinity of the perimeter berm at the northwest corner of the northern impoundments. Aerial photograph analysis suggests that this dredging occurred during the mid-to late 1990s.

For the northern impoundments and the aquatic environment, the chemicals of concern (COC) for human health include dioxins and furans, polychlorinated biphenyls (PCBs), and mercury. Dioxins and furans are the COCs for the ecological receptors. For the southern impoundment, the COCs are dioxins and furans for human health. Lead and zinc are the COCs for the ecological receptors at the southern impoundment area. Although there are separate COCs for the northern and southern impoundments, the Site is considered one Sitewide operating unit.

RISK SUMMARY

Ecological Risk

Baseline risks to ecological receptors associated with the wastes in the impoundments north of I-10 are the result of exposures to dioxins and furans localized to the immediate vicinity of the impoundments. Baseline ecological risks include reproductive risks to molluscs from exposure to TCDD, but localized, and surrounding the former waste impoundments, and low risks of reproductive effects in individual molluscs in sediments adjacent to the sand separation area. Results of the evaluation of post-TCRA ecological risks support the conclusion that localized exposures to the wastes in the northern impoundments is the primary driver of baseline ecological risk at the Site, and that therefore risks are localized, resulting from direct contact with the wastes in the northern impoundments.

Baseline risks include moderate risks to individual birds like the killdeer or spotted sandpiper, but low risk to populations. Baseline risks include risks to individual small mammals, but low to negligible risks to populations.

Baseline risks to benthic macro-invertebrate communities and populations of fish, birds, mammals, and reptiles resulting from the presence of metals, BEHP, PCBs, carbazole, and phenol on the Site are negligible. Risks to fish populations from all COPC_{ES} are negligible. Risks are also negligible to populations of wading and diving birds. Finally, there also are negligible risks to populations of terrestrial mammals such as the raccoon.

There are low to negligible risks to individual terrestrial invertivorous birds like the killdeer from exposure to zinc, and negligible risks to populations. In addition, the low probability of individual exposures exceeding effects levels indicates low risk to populations. There are also low to negligible risks to individual terrestrial invertivorous birds from exposure to dioxins and furans.

To the extent that risks from chemicals other than dioxins and furans occur on the Site, they are not associated solely with hazardous substances that may have been released from the former

impoundments. Substantial exposure of killdeer to zinc, and a variable fraction of the exposures of several receptors to PCBs, occurs in background areas. Implementation of the TCRA has reduced risks associated with dioxins and furans to negligible, but does not affect risks to killdeer from zinc.

Human Health Risk

Human health risks in the area of investigation north of I-10 (northern impoundments) were characterized for three hypothetical receptor groups: recreational fishers, subsistence fishers, and recreational visitors. The exposure media evaluated were sediments in four individual beach areas, soils throughout the entire area of the northern impoundments and edible fish and shellfish. For each receptor group, the potential for long-term exposure to COPC_{HS} was evaluated under baseline conditions (i.e., immediately prior to the TCRA). The evaluation was completed for a series of different hypothetical scenarios that address direct contact in different areas or ingestion of different types of tissue. Incremental risks from background, and reductions in risk resulting from completion of the TCRA, were also evaluated.

Dioxins and furans were identified as a risk driver in all media evaluated in the northern impoundments and the aquatic environment. PCBs in fish and shellfish tissue, and methylmercury in catfish tissue were additionally identified as COPC_{HS} that contributed substantially to potential risks associated with this area.

Results of the BHHRA generally indicate that hypothetical fishing and recreational exposure scenarios that assume direct contact with sediment within the original 1966 perimeter of the northern impoundments (i.e., termed “Beach Area E”) under baseline conditions would result in higher potential exposures to risk driving COPC_{HS}, than fishing and recreational scenarios in areas outside the 1966 perimeter (i.e., termed Beach Areas A, B/C, and D).

RME noncancer HIs greater than 1 were estimated for hypothetical fishing and recreational scenarios that assume direct contact with sediments at Beach Area E, however the CTE noncancer HIs for all potential receptors in this area were less than 1. Completion of the TCRA rendered sediments at Beach Area E inaccessible for direct contact by humans, and is also likely to have led to reductions in tissue concentrations in catfish and clams obtained from this area, substantially reducing any baseline risks in this area.

All estimated excess lifetime cancer risks for potential recreational fishers, subsistence fishers, and recreational visitors who were assumed to contact COPC_{HS} (other than dioxins and furans) in sediments and soils, and ingest fish or shellfish from the waters within USEPA’s Preliminary Site Perimeter were within or below USEPA’s target cancer risk range of 1×10^{-6} to 1×10^{-4} .

RME dioxin cancer HIs greater than 1 were estimated for all hypothetical fisher and recreational visitor scenarios that assumed direct contact to sediments at Beach Area E, however, the CTE cancer HIs for all hypothetical receptors in this area were less than 1. Again, completion of the TCRA rendered sediments at Beach Area E inaccessible for direct contact by humans, substantially reducing any baseline risks in this area.

Executive Summary

Hypothetical recreational and subsistence fishers exposed via direct contact with sediments at Beach Areas A, B/C and D were assumed to also ingest fish or shellfish from the adjacent fish collection area (FCA). Recreational visitors who contact sediments in one of the defined beach areas were assumed to also contact soils throughout the area under study.

This analysis indicated that no adverse noncancer health effects would be expected for hypothetical recreational visitors and recreational fishers as a result of contact with COPCHS in sediments at Beaches A, B/C, or D and soil throughout USEPA's Preliminary Site Perimeter, and consumption of fish or shellfish from the adjacent FCA. RME noncancer HIs for all COPCHS combined for hypothetical recreational fishers were below 1.

Noncancer HIs greater than 1 occurred only for the hypothetical subsistence fisher under the following scenarios: direct contact to sediments at Beach Area A in combination with ingestion of catfish from the adjacent FCA 2/3; direct contact to sediments at Beach B/C in combination with consumption of either catfish from the adjacent FCA 2/3 or clams from the adjacent FCA 2; and direct contact to sediments at Beach D in combination with consumption of catfish from FCA 1. For each of these scenarios, the predominant pathway of estimated exposure was the consumption of tissue. Potential risk driving COPCHS in tissue were dioxins and furans and PCBs in catfish and clams, and methylmercury in catfish.

All estimated excess lifetime cancer risks for COPCHS other than dioxins or furans on Beach Areas A, B/C, and D were within or below USEPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} . These included both RME and CTE cancer risks for the three hypothetical receptor groups.

It is not expected that dioxin-related cancer effects would have occurred under the baseline hypothetical recreational visitor and recreational fisher scenarios as a result of assumed contact with dioxins and furans in sediments at Beach Area A, B/C, or D and soil, and consumption of fish or shellfish from within USEPA's Preliminary Site Perimeter. RME cancer TEQDF HIs for these potential receptor groups were all below 1.

RME dioxin cancer HIs greater than 1 were limited to the hypothetical subsistence fisher receptor group under the following assumed scenarios: direct contact with sediments at Beach Area A in combination with ingestion of catfish from the adjacent FCA 2/3; direct contact with sediments at Beach Area B/C in combination with consumption of catfish from the adjacent FCA 2/3; and direct contact with sediments at Beach D in combination with consumption of catfish from FCA 1. For each of these hypothetical scenarios, consumption of tissue accounted for 95 percent or more of estimated COPCH exposure.

For the area of investigation on the peninsula south of I-10 (southern impoundment), risks were characterized for three potential receptor groups: trespassers, commercial workers, and future construction workers. The exposure medium evaluated for this area was soil. For each scenario, potential exposures were evaluated via direct contact with soil (i.e., ingestion and dermal contact). For the hypothetical future construction worker, noncancer and TEQDF cancer HIs were greater than 1 for scenarios that assumed exposure to exposure units DS-1, DS-2, and DS-4. For both the hypothetical commercial worker and trespasser scenarios, all cumulative risks are below 1×10^{-4} and noncancer and dioxin cancer hazards are below 1.

REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

The Remedial Action Objectives (RAO) for the Site include:

RAO 1: Eliminate loading of dioxins and furans from the former paper mill waste impoundments north and south of I-10, to sediments and surface waters of the San Jacinto River.

RAO 2: Reduce human exposures to paper mill waste-derived dioxins and furans to acceptable levels from consumption of fish and shellfish by remediating sediments affected by paper mill wastes to appropriate cleanup levels.

RAO 3: Reduce human exposures to paper mill waste-derived dioxins and furans to acceptable levels from direct contact with intertidal sediment by remediating sediments affected by paper mill wastes to appropriate cleanup levels.

RAO 4: Reduce human exposures to paper mill waste-derived dioxins and furans to acceptable levels from direct contact with upland soils to appropriate cleanup levels.

RAO 5: Reduce exposures of fish, shellfish, reptiles, birds, and mammals to paper mill waste-derived dioxins and furans by remediating sediment affected by paper mill wastes to appropriate cleanup levels.

RAO6: Prevent human exposure to ground water contaminants at concentrations above the MCL in the Southern Impoundment.

No potential pathway or risk for dioxin and furan transport to surface water or groundwater has been identified, and therefore no RAO for these media is necessary.

The Preliminary Remediation Goals (PRG) for the Site alternatives are based on toxic equivalents concentrations for dioxin and furan congeners using toxicity equivalency factors for mammals (TEQ_{DF,M}). The concentrations are protective of human health based on the Reasonable Maximum Exposure (RME) scenario for the subject hypothetical receptors. The PRGs for the Site include:

PRG for sediment in river: 220 ng/kg TEQ_{DF,M} (recreational visitor and recreational fisher scenarios).

PRG for soil/sediment in northern impoundment area: 1,300 ng/kg TEQ_{DF,M} (outdoor commercial worker and recreational visitor scenarios).

PRG for soil in southern impoundment area: 450 ng/kg TEQ_{DF,M} (construction worker scenario).

DESCRIPTION OF ALTERNATIVES

Area North of I-10

All of the alternatives for the area north of I-10, except Alternative 1N (No Further Action) and Alternative 5aN, include MNR for the river sediment area adjacent to the Upland Sand Separation Area located west of the northern impoundments. This area was used to process material previously dredged northwest of the Site and is already isolated from potential receptors by several feet of sediment with TEQ_{DF,M} concentrations below the PRG. However, the river

sediment area adjacent to the Upland Sand Separation Area is in a barge operations area and is subject to propeller wash by the tug boats moving the barges. Monitoring of sediment conditions in this area would be performed to confirm that deposition of clean sediment was continuing. The remedial action alternatives for the area north of I-10 include:

- **Alternative 1N** – TCRA cap, and Ongoing Operations, Monitoring, and Maintenance (OMM) (No Further Action). This alternative assumes the TCRA cap would remain in place, together with fencing, warning signs and access restrictions established as part of the removal, and would be subject to ongoing OMM. The estimated cost of this alternative is \$9.5 million. This estimate includes the cost of TCRA cap design and construction and USEPA 5-year reviews; these same costs are included in the estimate for each of the other alternatives for the area north of I-10.
- **Alternative 2N** – TCRA cap, Institutional Controls (ICs) and Monitored Natural Recovery (MNR). This alternative includes the actions described under Alternative 1N, ICs in the form of deed restrictions and notices, and periodic monitoring to assess the effectiveness of sediment natural recovery processes. This alternative is estimated to cost \$10.3 million.
- **Alternative 3N** – Permanent Cap, ICs and MNR. This alternative includes the actions described under Alternative 2N plus additional enhancements to strengthen the TCRA cap. This alternative will increase the long-term stability of the TCRA cap consistent with permanent isolation of impacted materials and meet or exceed USACE design standards. The Permanent Cap will use rock sized for the “No Displacement” design scenario, which is more conservative than the “Minor Displacement” scenario used in the TCRA cap’s design. This remedial alternative also includes additional measures to protect the Permanent Cap from potential vessel traffic (e.g., rock berm). This alternative would require an estimated 2 months of construction at an estimated cost of \$12.5 million. An off-site staging area may be required for management of rock armor materials, similar to that which was utilized during the removal construction.
- **Alternative 4N** – Partial Solidification/Stabilization, Permanent Cap, ICs and MNR. This alternative includes the actions described under Alternative 3N; however, about 23 percent of the TCRA cap (2.6 acres above the water surface and 1.0 acre in submerged areas) would be removed and about 52,000 cubic yards (cy) of materials with TEQ_{DFM} that exceeds a concentration 13,000 nanograms per kilogram (ng/kg), would undergo solidification and stabilization (S/S). After the S/S is completed, the Permanent Cap would be re-constructed and the same ICs and MNR as in Alternatives 2N and 3N would be implemented. This alternative would require an estimated 17 months of construction to complete and is estimated to cost \$23.2 million. An off-site staging area may be required for management of rock armor materials, stabilization reagents and associated treatment equipment.
- **Alternative 5N** – Partial Removal, Permanent Cap, ICs and MNR. This alternative includes partial removal of the TCRA cap and the same 52,000 cy of material that would undergo S/S under Alternative 4N would instead be excavated for off-site disposal. After the removal was completed, the Permanent Cap would be re-constructed and the same ICs and MNR that are part of Alternatives 2N to 4N would be implemented. This alternative would require an estimated 13 months of construction at an estimated cost of \$38.1 million. An off-site

materials management facility will be required for material staging, stabilization and processing for bulk transportation to an off-site landfill.

- **Alternative 5aN** - Partial Removal of Materials Exceeding the PRG, Permanent Cap, ICs and MNR. All material beneath the TCRA cap in any location where the water depth is 10-feet or less and which has a $TEQ_{DF,M}$ at or above the PRG for sediment of 220 ng/kg. About 137,600 cy of sediment would be excavated for off-site disposal. To implement this alternative, about 11.3 acres (72 percent) of the TCRA cap would be removed to allow for this material to be dredged. This alternative includes an engineered barrier to manage water quality during construction. In shallow water areas (water depths up to approximately 3 feet), this barrier would be constructed as an earthen berm. In areas with water depths deeper than about 3 feet, the berm would transition into a sheetpile barrier around the work area. Following removal of impacted sediment, the area from which sediments are removed would be covered with a residuals management layer of clean cover material, and the remaining areas of the cap would be enhanced, and the same ICs and MNR that are part of the preceding four alternatives would be implemented. This alternative would require an estimated 19 months for construction and has an estimated cost of \$77.9 million. An off-site materials management facility will be required for material staging, stabilization and processing for bulk transportation to an off-site landfill.
- **Alternative 6N** – Full Removal of Materials Exceeding the PRG, ICs and MNR. All material above the PRG of 220 ng/kg located beneath the TCRA cap or at depth in an area to the west would be removed. This would involve removal of the existing TCRA cap in its entirety and the removal of 200,100 cy of sediment. The dredged area would then be covered with a layer of clean fill. This alternative would require an estimated 16 months of construction at an estimated cost of \$99.2 million. An off-site materials management facility will be required for material staging, stabilization and processing for bulk transportation to an off-site landfill.

Area South of I-10

All of the alternatives for the Southern Impoundment, except the no action alternative, include a Technical Impracticability Waiver and deed restrictions restricting use of the shallow alluvial ground water. The remedial action alternatives for the area south of I-10 include:

The remedial action alternatives for the area south of I-10 include:

- **Alternative 1S** – No Action. This alternative only includes five-year reviews. The estimated cost is \$140,000.
- **Alternative 2S** – ICs. This alternative includes deed restrictions applied to parcels in which the $TEQ_{DF,M}$ exceeds the PRG within the upper 10-feet. The estimated cost is \$270,000.
- **Alternative 3S** – Enhanced ICs. This alternative would incorporate the ICs identified in Alternative 2S and add physical features to enhance the effectiveness of the ICs. The physical features would include bollards to define the areal extent of the remedial action areas at the surface and a marker layer that would alert workers digging in the area that

deeper soil may be impacted. The duration of construction is estimated to be 1 month and the estimated cost is \$660,000.

- **Alternative 4S** – Removal and Off-site Disposal. This alternative includes the removal of impacted soil from the surface to a depth of 10-feet. The removed volume is estimated to be 50,000 cy. Removal below the existing building (an elevated frame structure) and a concrete slab in the area would not be done and deed restrictions would be applied to this area where the $TEQ_{DF,M}$ exceeds the PRG within the upper 10-feet. The duration of construction is estimated to be 7 months and the estimated cost is \$9.9 million.

PREFERRED ALTERNATIVE

The preferred alternative for the northern impoundment area is a modified Alternative 5aN and the preferred alternative for the southern impoundment area is a modified Alternative 4S.

A modified Alternative 5aN is the preferred alternative to address the area north of I-10, including the northern impoundments. This alternative is shown in **Figure XX**. This alternative includes the following specific components:

- Soil/sediment in the northern impoundments footprint where the water depth is approximately 10 feet or less and with $TEQ_{DF,M}$ concentrations exceeding PRG (220 ng/kg), plus soils that exceed 13,000 ng/kg $TEQ_{DF,M}$ in any water depth, would be removed. The actual extent of the removal will be determined based on a Value Engineering evaluation of the sheet pile and berm location prepared during the Remedial Design.
- The soil/sediment would then be dewatered and transported to a permitted landfill for disposal.
- This alternative requires partial removal of the TCRA cap.
- Soil/sediment removal would be performed behind an engineered barrier, including a berm in shallow water areas and a sheetpile in deeper water areas.
- Following removal of the soil/sediment, a 6-inch thick residuals cover would be placed over the area.
- Permanent Cap enhancements would be constructed in the northern impoundments footprint where the PCL is exceeded but the water is deeper than 10-feet. The cap enhancements include adding additional armor rock to the cap, which will further flatten the slopes, and construction of a perimeter submerged rock barrier to protect the Permanent Cap from vessel traffic.
- The Permanent Cap will be designed to be protective under a 500 year flood event, and meet or exceed USACE and USEPA cap design criteria.
- Alternative 5aN would be modified by including the removal of the affected sediment near the Upland Sand Separation Area as described under Alternative 6. Following removal of the sediment, a 6-inch thick residuals cover would be placed over the area.

A modified Alternative 4S is the preferred alternative to address the southern impoundment area. This alternative is shown in **Figure 4-11**. This alternative includes the following specific components:

- Excavation and replacement of soil in three areas.
- Soil would be removed to a depth of 10-feet below grade except below the existing building and slab.
- Dewatering is required to allow excavation of the impacted soil.
- Effluent from dewatering may require treatment prior to disposal.
- Following further dewatering of the excavated soil as necessary, the soil will be transported for disposal at a permitted landfill.
- The excavation will be backfilled with clean soil and re-vegetated.
- Pavement on market Street adjacent to Remedial Action Area South-1 would be repaired.
- Alternative 4S would be modified so that no removal would be performed in the area of the existing building and concrete slab within Remedial Action Area South-3. Further, ICs would be placed to address the area below the building and concrete slab where the $TEQ_{DF,M}$ exceeds the PRG within the upper 10-feet.

STAKEHOLDER VIEWS

- Texas Commission on Environmental Quality:
- Harris County:
- Galveston Bay Authority (TAG):
- Texans Together (community group):

SITE NAME, LOCATION, AND DESCRIPTION

The Site consists of the northern impoundments, approximately 14 acres in size, built in the mid-1960s for disposal of paper mill wastes, and the surrounding areas containing sediments and soils potentially contaminated with the waste materials that had been disposed of in the impoundments. The northern impoundments are located on a 20-acre parcel on the western bank of the San Jacinto River, in Harris County, Texas, immediately north of the Interstate Highway 10 (I-10) Bridge over the San Jacinto River (Figure 2-1).

The area south of I-10 and on the west side of the San Jacinto River is an upland area, and the site of a former impoundment. The impoundment south of I-10 is not currently and has not been in contact with surface water. Since the 1960s, a variety of industrial and other activities have taken place on the upland area south of I-10. Most of the peninsula is currently in industrial or commercial use by marine services companies, with some parcels currently unused.

An armored cap was placed over the northern impoundments in 2011 during a TCRA. The cap includes layers of armor stone, geotextile and geomembrane and is constructed over an area of approximately 15.7 acres. The TCRA cap was designed to withstand a 100-year storm event with an additional factor of safety to ensure its long-term protectiveness.

SITE HISTORY AND ENFORCEMENT ACTIVITIES

Large scale groundwater extraction by others, resulting in regional subsidence of land in the vicinity of the Site, as well as dredging and sand mining by others within the river to the west of the northern impoundments through the 1990s and early 2000s. This area is known as the Upland Sand Separation Area.

The northern impoundments were constructed in 1965 by forming berms within the estuarine marsh to the west of the main river channel. The northern impoundments were divided by a central berm running lengthwise (north to south) through the middle, and were connected with a drain line to allow flow of excess water (including rain water) from the impoundment west of the central berm into the impoundments east of the central berm (Figure 1-1). In 1965 and 1966, paper mill wastes were transported by barge from the Champion Paper Inc. paper mill in Pasadena, Texas and unloaded into the northern impoundments for stabilization and disposal. The excess water collected in the impoundment located to the east of the central berm was pumped back into barges to be taken to another location. Prior to the initiation of the Remedial Investigation (RI), the wastes that were deposited in the impoundments were found to contain polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) (dioxins and furans), and some metals.

Physical changes in the 1970s and 1980s, including regional subsidence of land in the area due to large scale groundwater extraction and sand mining within the river and marsh to the west of the northern impoundments, resulted in partial submergence of the impoundments north of I-10 and exposure of the contents of the impoundments to surface waters. Based on review of USACE-approved dredging permits, dredging by third parties occurred in the vicinity of the perimeter

Detailed Summary

berm at the northwest corner of the northern impoundments. Aerial photograph analysis suggests that this dredging occurred during the mid- to late 1990s.

Southwest Shipyards, a barge maintenance and cleaning facility located on the eastern half of the peninsula south of I-10, adjacent to the southern impoundment, leased part of the upland sand separation area in 1996. The Southwest Shipyards facility south of I-10 performs cleaning and repair of barges used for transporting chemical and petroleum products. The area leased to Southwest Shipyards on the upland sand separation area was known as “C Yard” or the “barge painting area.” According to available records, C Yard included the shoreline area of the eastern side of the embayment on the upland sand separation area. An enforcement action against the Southwest Shipyards resulted in an Agreed Order with the Texas Natural Resources and Conservation Commission (TNRCC) dated August 28, 1997, TNRCC Docket No. 97-0453-IHW-E (1997 Agreed Order). The 1997 Agreed Order describes the failure of Southwest Shipyards to notify TNRCC, the predecessor to TCEQ, regarding generation and storage of unspecified hazardous wastes on C Yard and subsequent shipment of such wastes to the Southwest Shipyards’ property. A work plan prepared pursuant to the 1997 Agreed Order on behalf of Southwest Shipyards by GW Services (1997) states that Southwest Shipyards conducted barge painting operations on C Yard from October to December 31, 1996. The work plan (GW Services 1997) also describes wastes that may have been generated by the activities at C Yard; such wastes are thought to have included the residual spent blast sand, paint chips and rust chips swept from vessels prior to painting, paint drip, and overspray. At the time the work plan (GW Services 1997) was submitted, the embayment adjacent to Southwest Shipyards’ activities at C Yard was being dredged, and dredged materials were stockpiled on the upland sand separation area, although the specific location of the stockpile is uncertain.

In 2005 the Texas Parks and Wildlife Department (TPWD) referred the Site to TCEQ for investigation and remediation because sediment, water, fish, and crab samples indicated elevated dioxin levels near the I-10 bridge and because available information suggested the presence of waste pits in the area. The 2002 to 2004 sampling was done as part of a Total Maximum Daily Load (TMDL) study in the San Jacinto River for dioxin. The Site was subsequently placed on the National Priorities List (NPL) in 2008.

The U.S. Environmental Protection Agency (USEPA) issued a Unilateral Administrative Order (UAO), Docket No. 06-03-10, to International Paper Company (IP) and McGinnes Industrial Maintenance Corporation (MIMC) on November 20, 2009 (USEPA 2009a). The UAO directs IPC and MIMC to conduct a Remedial Investigation and Feasibility Study (RI/FS) for the San Jacinto River Waste Pits Superfund Site in Harris County, Texas.

The Potentially Responsible Parties (PRPs) for the Site, MIMC and IP implemented a time critical removal action (TCRA) to stabilize and isolate materials within the northern impoundments. The TCRA was completed in 2011 pursuant to the terms of an Administrative Settlement Agreement and Order on Consent for Removal Action: CERCLA Docket No. 06-12-10 (AOC; USEPA 2010a). The TCRA included construction of a armored cap, installation of security fencing, establishment of access controls, and the posting of warning signs. The TCRA cap included an underlying stabilizing geotextile barrier over the eastern and western cells, and a low-permeability geomembrane in the western cell.

The TCRA cap, and associated fencing, access controls and signs have been routinely inspected and maintained pursuant to an operation, monitoring, and maintenance (OMM) plan. The OMM Plan was developed to address conditions that could occur post-construction (such as movement of rock cover of the cap). The OMM Plan requires periodic monitoring, as well as monitoring following key storm events, to identify the need for possible cap maintenance and procedures to implement appropriate repair activities.

In mid-2011 during the final stages of the cap construction, the San Jacinto River Fleet established a barging operation in the waters and at the shoreline surrounding the upland sand separation area (Figure 1-1). The San Jacinto River Fleet's operations include intensive use of tugboats to move barges around the upland sand separation area, including directly in the area where this investigation found the sediments with the highest dioxin and furan concentrations outside of the original 1966 perimeter of the impoundments north of I-10.

In July 2012, early in the cap post-construction period, a minor storm occurred that resulted in erosion of a portion of the armor layer (the rock above the geotextile layer) of the cap. In some areas the armor material was completely removed exposing the underlying geotextile material, however, the geotextile remained intact and there was no release of the dioxin contaminated waste material beneath the cap. The affected areas totaled about 200 square feet, or 0.03 percent of the overall area of the cap. The cap was then repaired, initially, in accordance with the OMM Plan.

Subsequently, the U.S. Army Corps of Engineers (USACE) prepared a review of the design and construction of the TCRA cap. The USACE review stated that the storm and flood was estimated to be a 10-year return event. A 10-year return event has a 10% chance of occurring in any one year, and is of a lesser intensity than the design 100-year return event, which has a 1% chance of occurring in any one year. The USACE review determined that the slope was too steep in the western berm area for the armor material used, and that the slope should be 1-vertical:3-horizontal or flatter to prevent excessive displacement and loss of gravel and sand sized particles. Further, the USACE found that the cap material specifications allowed too much gravel and sand sized particles to be used, which could be eroded from the cap because they did not meet internal stability and retention criteria, and that greater uniformity of the armor cap is preferable in the high energy regimes of the cap, particularly the southwestern corner of the berm. In January 2014, the armor cap was upgraded by implementing all of the USACE recommendations.

NATIONAL PRIORITIES LIST

The Site was proposed for listing on the NPL on September 19, 2007 (72 FR53509), and was placed on the NPL effective March 19, 2008 (73 FR 14719).

SCOPE AND ROLE OF RESPONSE ACTION

This response action is the final Site remedy and is intended to address fully the threats to human health and the environment posed by the conditions at this Site. The purpose of this response action is to implement a site-wide strategy to:

Detailed Summary

- Eliminate releases of dioxins and furans from the waste impoundments to sediments and the San Jacinto River.
- Reduce human exposures to Site COCs from consumption of fish and shellfish.
- Reduce human exposures to Site COCs from direct contact with sediments.
- Reduce human exposures to Site COCs from direct contact with upland soils.
- Reduce exposures of fish, shellfish, reptiles, birds, and mammals to Site COCs.

A TCRA program involving capping and isolation of the wastes in the impoundments north of I-10 was completed in July 2011. The purpose of the TCRA was to stabilize the entire area within the original 1966 perimeter of the impoundments north of I-10 (Figure 1-2), until a final remedy is implemented. Aerial images of the affected area before and after construction on July 14, 2011 are shown in Figure 1-3. The following objectives were identified for the TCRA:

- Stabilize waste impoundments to withstand forces of the river.
- Technologies for the cap must be structurally sufficient to withstand a storm event with a return period of 100 years until the nature and extent of COCs for the area within USEPA's Preliminary Site Perimeter is determined and a final remedy is implemented.
- Prevent direct human contact with the waste materials.
- Prevent benthic contact with the waste materials.

SITE CHARACTERISTICS

Site Overview

The San Jacinto River drains an area of 3,900 square miles and supplies approximately 28 percent of the fresh water entering Galveston Bay. The mainstem of the San Jacinto River, downstream from the Lake Houston dam in northeastern Harris County, flows southeast for 28 miles to its mouth on Galveston Bay east of Houston. The 9-mile-long Lake Houston and the river below it are formed by the confluence of the 69-mile-long East Fork and the 90-mile-long West Fork of the San Jacinto rivers. The dam that forms Lake Houston is an earthfill dam that is 62 feet high with a concrete spillway. The reservoir that is created by the dam is used for recreation, as well as an industrial, municipal, and agricultural water supply.

Tropical weather systems can have tremendous impacts on regional precipitation and hydrology along the Gulf Coast. Hurricane season runs from June 1 to November 30. Between 1851 and 2004, 25 hurricanes have made landfall along the north Texas Gulf Coast, seven of which were major (Category 3 to 5) storms. Tropical Storm Allison, which hit the Texas Gulf Coast on June 5 through 9, 2001, resulted in 5-day and 24-hour rainfall totals of 20 and 13 inches, respectively, in the Houston area, resulting in significant flooding. More recently, Hurricane Rita made landfall on September 23, 2005, between Sabine Pass, Texas, and Johnsons Bayou, Louisiana, as a Category 3 storm with winds at 115 mph and it continued on through parts of southeast Texas. The storm surge caused extensive damage along the Louisiana and extreme southeastern Texas coasts. On September 13, 2008, the eye of Hurricane Ike made landfall at the east end of Galveston Island and travelled north up Galveston Bay, along the east side of Houston. Ike made its landfall as a strong Category 2 hurricane, with Category 5-equivalent storm surge, and hurricane-force winds that extended 120 miles from the storm's center.

Detailed Summary

Flow rates in the San Jacinto River in the vicinity of the Site are partially controlled by the Lake Houston dam, which is located about 16 river miles upstream of the northern impoundments. The average flow in the river is 2,200 cfs. The river in the vicinity of the Site is affected by diurnal tides, with a typical tidal range of about 2 feet. Floods in the river occur primarily during tropical storms (e.g., hurricanes) or intense thunder- storms. Extreme flood events have flow rates of 200,000 cfs or greater. Floods can cause water surface elevations to increase by 10 to 20 feet or more (relative to average flow conditions).

Between October 14 and October 21, 1994, heavy rainfall occurred in a 38-county area of southeast Texas. The San Jacinto River basin received 15 to 20 inches of rain during this week-long period, and had a peak discharge of 360,000 cfs, which is a return period greater than 100 years. The river stage height during the October 1994 flood had a maximum value of 27 feet at the Sheldon, Texas streamflow station, located north of the Site. Another storm occurring in 1940 had a river stage height of 31.50 feet at the same Sheldon location.

The 1994 flooding caused major soil erosion and created water channels outside of the San Jacinto River bed. Over 3,000 homes were destroyed and another 15,000 damaged. Railroad and highway roadbeds and bridges, and oil and gas pipelines, sustained major damage. This flooding caused eight pipelines to rupture and 29 others were undermined at river crossings and in new channels created in the flood plain. The largest new channel was cut through the Banana Bend oxbow just west of the Rio Villa Park subdivision. This new channel was about 510-feet wide and 15-feet deep. A second major channel cut through Banana Bend just north of the channel through the oxbow. Both of these new channels were cut through areas where sand mining had been done before. Sonar tests in a 130-foot section south of the I-10 bridge located adjacent to the Site found about 10 to 12-feet of erosion in the river bed.

The U.S. Department of Transportation undertook a nationwide riverbed erosion risk assessment study using a potential scour depth model in an effort to identify pipelines with a higher probability of failure due to natural disasters. The study provided an indicator of scour potential rather than an estimate of absolute scour depths. The study defined an “erosion hazard” from 0 to 100. Areas with the highest rank in scour depth and the highest rank in annual chance of flooding have an erosion hazard of 100. The study found that the erosion hazard for the area around the Site ranges between 95 and 100.

Wildlife habitats on the northern portion of the Site include shallow and deep estuarine waters and shoreline areas occupied by estuarine riparian vegetation. Minimal habitat is present in the upland terrestrial area west of the impoundments, as sand sorting activities created a denuded upland area with a covering of crushed cement and sand, and as a result of the current barge fleeting operation there. Estuarine riparian vegetation lines the upland area that runs parallel to I-10. To the west of the central berm within the impounded area, the area is currently occupied by late successional stage vegetation, and to the east the historically impounded area is consistently submerged even at low tide.

South of the dam at Lake Houston, the San Jacinto River, including the Site area, is tidally influenced. The area south of the Site is dominated by the Houston Ship Channel (HSC) and the industrial sites that are served by the barges and ocean-going vessels that use the HSC. From the Site to Lake Houston there is much less industrialization along the river. The water quality

Detailed Summary

segments upstream and downstream include the following uses: aquatic life, general, recreation and restricted fish consumption.

Lynchburg Reservoir, located on the east bank of the San Jacinto River just south of the I-10 Bridge and the Site, uses water pumped in from the Trinity River. It is owned by the City of Houston, and construction was completed in 1976. At normal levels the lake has a surface area of 200 acres. The lake dam is earthen construction, with a height of 35 feet and a length of 15,315 feet. The lake drains an area of 0.32 square miles. Also located south of the I-10 bridge is Lost Lake, located between the primary channel of the San Jacinto River and the Old Channel to the west. Lost Lake is not a surface water reservoir; rather, it is a confined disposal facility (CDF) for sediments from the HSC maintenance dredging program. It is managed by the Port of Houston Authority and U.S. Army Corps of Engineers (USACE), Galveston District.

The Site consists of the northern impoundments, approximately 14 acres in size, built in the mid-1960s for disposal of paper mill wastes, and the surrounding areas containing sediments and soils potentially contaminated with the waste materials that had been disposed of in the impoundments. The northern impoundments are located on a 20-acre parcel on the western bank of the San Jacinto River, in Harris County, Texas, immediately north of the Interstate Highway 10 (I-10) Bridge over the San Jacinto River (Figure 2-1). The depth of the channel of the San Jacinto River is deeper than the depth of the base of the impoundments.

The area south of I-10 and on the west side of the San Jacinto River is an upland area, and the site of a former impoundment. The impoundment south of I-10 is not currently and has not been in contact with surface water. Since the 1960s, a variety of industrial and other activities have taken place on the upland area south of I-10. Most of the peninsula is currently in industrial or commercial use by marine services companies, with some parcels currently unused.

In 1965 and 1966, pulp and paper mill wastes (both solid and liquid) were transported by barge from the Champion Paper Inc. paper mill in Pasadena, Texas and unloaded at the Site into the impoundments where the waste was stabilized and disposed. The excess water from the northern impoundments was pumped back into barges and taken off-Site. The Champion Paper mill used chlorine as a bleaching agent, and the wastes that were deposited in the impoundments were found to be contaminated with polychlorinated dibenzo-p-dioxins, polychlorinated furans (dioxins and furans), and some metals.

Physical changes at the Site in the 1970s and 1980s, including regional subsidence of land in the area due to large scale groundwater extraction and sand mining within the river and marsh to the west of the impoundments, have resulted in partial submergence of the impoundments north of I-10 and exposure of the contents of the impoundments to surface waters. Based upon review of U.S. Army Corps of Engineers (USACE)-approved dredging permits, dredging by third parties has occurred in the vicinity of the perimeter berm at the northwest corner of these impoundments.

The TCRA cap was placed over the northern impoundments in 2011. The cap includes layers of armor stone, geotextile and geomembrane and is constructed over an area of approximately 15.7 acres. The TCRA cap was designed to withstand a 100-year storm event with an additional factor of safety to ensure its long-term protectiveness.

Detailed Summary

The northern impoundments were constructed on the inside bend of a natural river oxbow, in an area historically consisting of marshlands. This area was likely a zone of sediment accretion rather than erosion with hydrodynamic energy being directed through the main river channel in the far eastern portion of the Site (i.e., along the outside bend of the oxbow).

The first fish advisory for this area, ADV-3 was issued by the Texas Department of Health (TDH) in 1990 based on dioxins in catfish and blue crabs. This advisory was re-evaluated in subsequent years based on new monitoring data and continues to be in effect today. In addition, in 2001, ADV-3 was augmented by a new advisory, ADV-20, also covering waters within then Site area. ADV-20 addressed consumption of all species of finfish due to the presence of elevated concentrations of organochlorine pesticides and PCBs. In 2005, an additional advisory, ADV-28 was issued for spotted seatrout from these waters due to PCBs. Detailed descriptions of all restrictions are posted on signs at locations along the river. In all but one of these areas, the river is considered suitable for aquatic life and recreation.

Conceptual Site Model (CSM) – Northern Area and Aquatic Environment

A CSM for a Site provides a depiction of the sources of contaminants, the physical-chemical processes that control chemical transport and fate over time and space, and the exposure pathways that potentially lead to exposure and adverse effects to ecological and human receptors. The CSM for the area north of I-10 and aquatic environment is shown in Figure 1-1. Figure 2-2 identifies the potential routes of human exposure in detail. For this area, hypothetical recreational and subsistence fishers, recreational visitors, and trespassers were identified as groups that may have contact with impacted media under baseline conditions. These hypothetical receptors represent a range of exposure types and intensities that could occur in the area north of I-10 and aquatic environment. For instance, the hypothetical subsistence fisher and hypothetical recreational fisher are assumed to be exposed to COCs via similar pathways. However, the hypothetical subsistence fisher is assumed to frequent the area more often, and consume a larger number of fish and shellfish from the area under evaluation compared to the hypothetical recreational fisher. The hypothetical recreational visitor and hypothetical trespasser are also assumed to be exposed to COCs via the same exposure pathways as one another; however, the hypothetical recreational visitor is assumed to be exposed at a greater frequency and duration relative to the trespasser.

Potential inhalation of COCs in air and exposure via direct contact with surface water were defined as minor pathways for the Site. Inhalation exposure via vapor inhalation is considered minor because none of the COCs identified are volatile compounds and, therefore, would not tend to volatilize into ambient air. While inhalation of particulates derived from the resuspension of surface soil may occur, this pathway generally contributes less than one percent of total estimated exposure when direct soil contact pathways (ingestion and dermal contact) are considered. Exposure to COCs in surface water is also considered to be a minor pathway for this site. This is because the primary COCs, dioxins and furans, are hydrophobic, are not soluble in water, and tend to be tightly bound to the organic carbon fraction of sediments. It is possible that individuals could be exposed to COCs that adsorb to suspended sediment particles in the water column, but those exposures would be brief and minimal because the movement of the surface

Detailed Summary

water will continually wash away the majority of the sediment particles that contact the skin, leaving little opportunity for absorption.

Fishing activity within the waters surrounding the Site has been observed and fishers in this area have been reported to collect whatever they catch. Fishing is reported to have been popular at the northern tip and along the northeast side of the area of the northern impoundments prior to implementation of the TCRA. People were observed to wade out in the water on the east side and fish and use crab cages in this area. Prior to implementation of the TCRA, fishing was reportedly also observed to the south of the northern impoundments area and under the I-10 Bridge, on both sides of the channel. Other points of fishing access near the Site include RV trailer parks on the east side of the river north of I-10 that provide access to the river, and a public access area at Meadowbrook Park to the west.

Although the lands near the Site are largely privately owned, points of access were available to the public along and within this area prior to the TCRA. Such access allowed for a variety of recreational activities other than fishing, including picnicking, walking, bird watching, wading, and boating. Shoreline use and wading near the Site were observed. Recreational visitors could potentially be exposed via the same direct contact exposure routes as fishers (i.e., incidental ingestion of and dermal contact with soils and sediments). However, these individuals are not exposed via ingestion of fish or shellfish.

Signs of trespassing have been reported in some areas within the area of the Site, particularly under the I-10 Bridge. Consistent with the hypothetical receptors addressed by the HHRA representing a spectrum of potential assumed exposures, the hypothetical trespasser is the receptor used to represent a very low level of possible exposure. Therefore, although a hypothetical trespasser could be exposed via the same pathways as the recreational visitor (i.e., direct contact pathways) and recreational fisher (i.e., ingestion of fish and shellfish), the concept of the trespasser is that of a person whose exposure would likely be intermittent and of a shorter term than the exposures being evaluated for either of those scenarios. Thus, for the area north of I-10, the estimated risks and hazards presented for the hypothetical fishers and hypothetical recreational visitors are higher than and would overstate potential risks for hypothetical trespassers. For this reason the hypothetical trespasser scenario was not evaluated quantitatively for the area north of I-10 and aquatic environment.

Conceptual Site Model – Southern Area

The CSM for the peninsula south of I-10 is shown in Figure 1-2. Figure 2-3 describes the specific routes of potential exposure in detail. For this area, trespassers and commercial workers were identified as groups that may potentially come into contact with impacted media. Future construction workers may also potentially come into contact with the impacted soil.

With signs of trespassing in areas along the western bank of the River, it is possible that trespassers might walk around or spend time in the peninsula south of I-10. Because such activities might result in direct contact with surface soil, potentially complete exposure pathways for the trespasser are incidental ingestion and dermal contact with soil. Because fencing and active management and use of industrial properties south of I-10 make this area largely inaccessible, it is anticipated that the trespasser's exposure would be infrequent (i.e., an average

Detailed Summary

of 24 times throughout the year). Also it is likely that trespassing activities by any given individual would be limited to a relatively short time frame (i.e., no more than a few years).

Land use on the peninsula south of I-10 is commercial/industrial. Commercial workers, who perform maintenance or other work-related outdoor activities, might have potential direct contact with surface and shallow subsurface soil. Potentially complete exposure pathways for the commercial worker are incidental ingestion and dermal contact with surface and shallow subsurface soil.

In the future, construction work could occur on the peninsula south of I-10. Under this future scenario, hypothetical construction workers might have direct contact with surface and subsurface soil. Potentially complete exposure pathways for the construction worker are incidental ingestion and dermal contact with surface and subsurface soils.

Surface Water Hydrology

In the vicinity of the Sits, the San Jacinto River is an estuarine system with the primary freshwater inflow occurring at the Lake Houston Dam. Water depths in the area of the Site range from relatively shallow in intertidal areas (3-feet or less) to relatively deep in the main channel of the river (about 30-feet). The average flow rate at the dam is 2,600 cubic feet per second (cfs). Peak flow rates during the 2- and 100-year floods in the San Jacinto River are 38,400 and 372,000 cfs, respectively. On October 19, 1994, a flow rate of 356,000 cfs was measured in the San Jacinto River at the USGS gauging station north of the Site located at the US 90 Bridge near Sheldon, Texas. Peak flow rate at the dam during Tropical Storm Allison (June 10, 2001) was 80,500 cfs (5-year return period). During Hurricane Ike (September 15, 2008), the flow rate was 63,100 cfs (2- to 5-year flood).

Water surface elevation in the San Jacinto River is affected by the following processes: tides, hurricane storm surges, and floods on the river. The typical tidal range is about 2 feet, with hurricane storm surges usually causing increases in water depth of 4 to 6 feet. Floods can cause water surface elevations to increase by 10 to 20 feet or more.

The San Jacinto River is a well-mixed estuary with minimal vertical gradients in salinity. This characteristic means that the extent to which density-driven circulation (i.e., two-layer flow) occurs in the river is limited. Average salinity typically ranges between 10 and 20 ppt near Morgan's Point at the mouth of the San Jacinto River. Salinity ranged between about 2 and 12 ppt in the San Jacinto River near the I-10 Bridge. During flood conditions, salinity may decrease to close to 0 ppt in parts of the San Jacinto River from the large volume of freshwater flowing past Lake Houston Dam.

Sediment Overview

The primary source of sediment to the San Jacinto River is the incoming load at the Lake Houston Dam. The average annual sediment load at the dam is estimated to be 381,000 metric tons/year. The annual load at the dam is highly variable, with lower loads during low-flow years and higher loads during high-flow years. During the 21-year period from 1990 through 2010, the annual sediment load was estimated to vary between about 78,000 and 1,500,000 metric

Detailed Summary

tons/year. Sediments entering the San Jacinto River from Lake Houston can be transported in the water column as suspended sediment, and interact with the sediment bed through deposition and erosion processes.

The nature of the sediment bed affects sediment transport processes (as well as chemical distributions, because dioxins and furans preferentially bind to finer sediments having a higher organic carbon content). Based on bed probing and grain size data, the sediment bed within the Site area is composed of cohesive (i.e., muddy) and non-cohesive (i.e., sandy) sediments, with about 80 percent of the area having a cohesive bed. Within cohesive bed areas, the average clay/silt content in the bed is about 51 percent, with the remaining 49 percent containing sand and gravel. Non-cohesive bed areas are coarser, with average clay/silt and sand/gravel contents of 11 percent and 89 percent, respectively. Average dry densities of cohesive and non-cohesive bed areas are 0.83 and 1.4 g/cm³, respectively.

Site Geology and Hydrogeology

In the Site area, the surface and underlying local soils include Holocene alluvial deposits and the deeper Beaumont formation. Within the western cell of the impoundments north of I-10 and beneath the gray clay-like paper mill waste material, a very soft, dark gray and black silty clay unit was encountered. This unit ranges in thickness from 2 to 8 feet and contains fibrous organic matter. This unit consists of the former marsh soils, was encountered in all borings advanced in the tidally influenced zone, and was not encountered in the in-water borings.

The upper sediment layer in the water over the eastern part of the northern impoundments consists of varying, stratified deposits of soft silt and clay, with occasional layers of sand. This soft clay and silt were observed from the mudline down to an elevation of –26 feet North American Vertical Datum of 1988 (NAVD88), and range in thickness from 13 to 22-feet in the water, and 0 to 10 feet on the land. This layer varies in color from gray to brown, to almost black and contains varying amounts of organic fibers, from trace to abundant.

At most boring locations, underlying the soft silt and clay, was a layer of loose to medium dense, light gray sand. This sand layer is generally slightly silty, with fine- to medium-grained, sub-rounded particles. Occasionally, interbeds of gray clay were observed within this unit. The light gray sand unit ranges in thickness from 6 to 16.

The Beaumont clay is a hard, dry to damp clay layer present from elevations –24 to –65 feet NAVD88, and ranged in thickness from 27 to 41 feet. This material was light reddish-brown in color and graded to light-bluish-gray with depth. There was an occasional trace of sand and silt in the reddish-brown clay. The thickness and extent of the Beaumont Formation are shown on Figure 2-7.

The Beaumont sand layer was found underneath the Beaumont clay layer. This sand unit consisted of medium to very dense, light gray, silty sand with pockets of clay and was observed from elevations –56 to –130 feet NAVD88. Below the Beaumont sand is a light bluish-gray layer of hard clay. This lower layer of hard clay was observed from elevation –95 feet NAVD88 to the bottom of the exploration at –124 feet NAVD88 in SJGB007. An 11-foot-thick layer of

Detailed Summary

this unit was observed in boring SJGB003 from –110 to –121 feet NAVD88. This material was very similar to the upper hard clay unit in terms of plasticity and grain size.

The local water table (i.e., shallow groundwater) is found near land surface in the shallow alluvium sediments, generally at the approximate elevation of the San Jacinto River water surface. Groundwater movement in the shallow alluvium in the Site area is dominated by surface water/groundwater interactions with the river, which surrounds the former impoundments. The Beaumont Formation under the Site is a confining unit that isolates shallow groundwater in the Holocene alluvium and in the San Jacinto River sediments from the underlying formations of the Chicot Aquifer.

The clay-like paper-mill waste material within the northern impoundments has hydraulic conductivity (K) results from three boring tests ranging from 3.81×10^{-6} cm/sec to 8.39×10^{-7} cm/sec. These values are typical of fine silt to course clay.

In the southern impoundments, the shallow zone is a heterogeneous mix of predominantly silt- and clay-size material with lesser amounts of medium to coarse sand and gravel, and finally, fine and very fine sand. From 10 to 16-feet of fill was placed on top of or mixed into the top of natural alluvial sediments below. Debris that is not typical of paper mill waste was observed in approximately two-thirds of the 26 cores in the southern impoundment area. This debris included plastic sheeting, glass, wood, rubber, shells, brass fittings, asphalt, and paint chips. Some petroleum hydrocarbon odor and sheen was also observed. Most of the debris was encountered between 5 and 10 feet bgs in the dark gray sandy silt and clay, but some was also encountered at shallower and deeper depths. The debris found at depths between 10 and 13 feet bgs was in cores placed in a location near what appear to be trenches in the 1964 aerial photograph. The deepest debris was found in two adjacent cores (SJSB013 and SJSB017) along the west side of the southern impoundment, where crushed woody debris was found at approximately 17 feet bgs.

In the northern impoundment area, groundwater flows in the shallow alluvium are approximately congruent with localized surface topography (Figure 3-17), and discharge as expected generally to the San Jacinto River, although periods of high tides or flood conditions may temporarily and locally reverse shallow groundwater flow gradients. Deep well water level data indicate a general southeast regional flow, as shown in the Chicot Aquifer potentiometric surface in Figure 3-17), consistent with the regional deep groundwater flow direction noted in USGS.

The shallow groundwater (shallow alluvium zone) in the northern impoundments is typically salty, with the total dissolved solids (TDS) ranging between 9,954 mg/L and 11,535 mg/L. The shallow groundwater is not used within 0.5 miles of the Site. The groundwater zone below the Beaumont clay has TDS ranging between 2,284 and 12,550 mg/L. Similar to the shallow groundwater zone, groundwater from the deeper zone is not used within 0.5 mile of the Site.

Sources of Contamination

The impoundments at the Site received pulp mill wastes in the mid-1960s and are the major source of COCs at the Site. Major physical changes resulted in the exposure of the wastes deposited within the impoundments to surface waters and the distribution of contaminated material into nearby surface sediments. Land subsidence resulting from regional groundwater

Detailed Summary

withdrawal in the 1960s and 1970s contributed to the sinking of the impoundments. As a result of this event, contaminated material was distributed and became distributed and potentially accessible to ecological receptors and to people at the Site. Material from the berm and from within the impoundment was subject to mobilization and redistributed by erosion resulting from tidal and river currents. Dredging activities in the area may have affected the Site. Mobilization of materials by dredging may have released sediment-associated contaminants to the water column that would have settled to the bottom.

Dioxins have never been purposely manufactured. They are anthropogenically and naturally produced through combustion, bleached paper production, polyvinyl chloride (PVC) production, ink/dye production, metal smelting, or as trace impurities or incidental by-products in chlorophenols, chlorinated herbicides, and commercial PCB. Examples of combustion and incineration that may lead to the formation of dioxins include waste incinerators, cement kilns, boilers and industrial furnaces, vehicle emissions, fossil fuel power plants (e.g., coal), and backyard burning (e.g., refuse piles, burn barrels). Dioxins are naturally produced from forest fires, volcanic eruptions, and sedimentary deposits. Currently the largest source of dioxins to the environment is from combustion. Absent a local source (such as the Site waste impoundments), the global source of dioxins and furans in environmental media is generally atmospheric deposition.

Additional local sources not related to the Site impoundments are also present. A permitted wastewater outfall from the Baytown Water Treatment Authority is present along the eastern shore of the area near the Site, north of I-10. An effluent sample was collected from this Baytown facility outfall by TCEQ, and the dioxin fingerprint is shown in [Figure 6-27](#).

Surface water drainage channels through the Lyondell and Equistar chemical manufacturing facilities receive flows from numerous stormwater outfalls draining the surrounding areas. Both of these drainage channels enter the San Jacinto River upstream of the Site. Dioxin fingerprints of sludges from the Lyondell and Equistar facilities are shown in [Figure 6-27](#).

Although the Equistar, Lyondell, and Baytown facilities, the other wastewater outfalls near the Site, and the numerous stormwater outfalls are not known to be “major” sources of dioxins and furans to the Site, the unmixing analysis described below identified two major types of dioxin and furan sources, one of them with a congener pattern very similar to sludge and effluent samples from these facilities, and similar to a generalized urban background associated with diesel exhaust, tire burning and other urban, pyrogenic sources ([Figure 6-23](#)). The background soil study in Burnet Park and the I-10 Beltway 8 Green Space demonstrated that dioxins and furans are in soil that have no influence from the Site ([Table 6-47](#)), suggesting that urban background influences on soils, and by extension sediments, can be present in terms of overall dioxin and furan load.

An unmixing analysis is a quantitative method that calculates the most likely composition of a specific number of different source materials that would have given rise to the observed sample data. In effect, the unmixing analysis “unmixes” the samples, estimating the composition of the source materials that would have been mixed in different proportions to produce all of the observed samples, and evaluating each sample to determine the contribution of each source material to the mixture observed in the sample. An unmixing analysis does not produce any

Detailed Summary

information about the history of source contributions or mixing events. Also, it is expected that the concentrations of the source materials have not significantly changed over time because the degradation rates of dioxins and furans are very slow, and the rate of any degradation of individual congeners that could have occurred would not significantly vary between the source materials.

An unmixing analysis was carried out using data for the seventeen dioxin and furan congeners in all sediment samples collected within and around the Site since 2009, and for all of the soil samples in the Texas Department of Transportation (TxDOT) right of way (ROW), and north of I-10. Dioxin and furan patterns, or fingerprints, were calculated for each sample by dividing the concentration of each individual congener by the sum of concentrations of all 17 congeners.

The unmixing analysis identified two original source materials that are quite different. One of these (EM1) is characterized by a relatively high proportion of OCDD, and the other (EM2) is characterized by a relatively smaller proportion of OCDD and relatively higher proportion of TCDD and TCDF. For a perspective on the relevance of the source materials identified in the unmixing analysis to sources of dioxins and furans in the environment, the dioxin/furan patterns of the two identified source materials were compared to fingerprints of known anthropogenic sources of dioxins. The EM1 dioxin/furan pattern was nearly identical to several pyrogenic sources in generalized urban and industrial emissions, such as diesel exhaust, oil-fired boilers, and tire combustion. This pattern combines multiple sources characteristic of generalized urban background sources. On the other hand, the fingerprint of EM2 is highly similar to many of the samples collected from within the northern impoundment perimeter, in particular those with highly elevated total dioxin composition, and elevated TEQ concentrations. This similarity in the pattern of EM2 with those of samples taken directly from waste materials within the northern impoundment perimeter indicates that EM2 is an indicator for the waste material from the impoundments.

Of the 546 samples of sediment and soil chemistry evaluated by the unmixing analysis, the results indicated that 176 samples (including many of the samples within the 1966 perimeter of the impoundments north of I-10) had no detectable potential influence by the waste from the impoundments.

To investigate the overall spatial pattern of the unmixing results, the fractional contribution of each source material is presented into a pie- chart graphic and plotted on a map using geographical coordinates for the actual sample location (Figure 6-29). For locations where both surface and subsurface samples are available, the interval with the largest contribution from the waste-related EM2 is shown, to depict the largest possible spatial extent of potential effects of paper mill waste from the impoundments north of I-10 to the surrounding soils and sediments. These results demonstrate that samples potentially affected by the source represented by the EM2 pattern (the paper mill wastes) are not confined to within the perimeter of the 1966 impoundment (Figure 6-29), but the majority of samples are confined to within the impoundment perimeter. The existence of an additional source of dioxins and furans to the sediments of the San Jacinto River system beyond the former waste impoundment north of I-10 is illustrated by the ubiquitous presence of significant amounts of dioxins and furans from EM1 (generalized urban sources) in all of the sediment and soil samples evaluated.

Detailed Summary

Contamination Description

Within the area of the northern impoundment that emerges above the tide line, on the west of the central berm, TEQ_{DF} concentrations in cores range from 3.37 ng/kg to 26,900 ng/kg. At Station SJGB012, the TEQ_{DF} concentration at the deepest interval is 17,000 ng/kg, suggesting that the core did not reach the deepest extent of the wastes in this part of the western cell. However, the TEQ_{DF} concentration at the deepest interval in SJGB010 and SJGB011 are 194 ng/kg and 3.37 ng/kg, respectively, much lower than the TEQ_{DF} concentrations in the overlying intervals, indicating that these cores approached or reached the bottom of the waste deposit.

The sharp decline in concentration between intervals towards the bottom of cores where elevated concentrations were found in the upper 6 to 10 feet suggests that the waste is consolidated within the northern impoundments, and not dispersing through the natural sediment below the waste. It also indicates that these cores were successful in defining the vertical extent of wastes. The cores from within the northern impoundment perimeter for which TEQ_{DF} concentration at all intervals is below the reference envelope value (REV) indicates that the eastern extent of the wastes is limited, even within the northern impoundment perimeter. The concentration of wastes at depth, and with a limited eastern extent is consistent with the Site history, which described the eastern cell as an area used to hold liquid wastes drained from the western cell, which was used for consolidation of solid wastes.

The sediment dioxin concentrations were found to decrease moving away from the waste impoundments (Figure 3).

Dioxin Fate and Transport

Dioxins and furans are a family of polychlorinated organic chemicals with similar chemical structures. They are characterized by extremely low vapor pressures, high octanol-water and organic carbon partitioning coefficients (K_{ow} and K_{oc}, respectively), and extremely low water solubilities. These factors indicate a strong affinity for sediments, particularly sediments with high organic content, and for lipids within biological tissue. Although some dioxins deposited on or near the water surface will be broken down by sunlight, and a very small portion will evaporate to air, the vast majority will sorb strongly to particulate matter, including organic matter, and eventually settle to the sediment bed, where they will be subject to sediment transport processes. After they are sorbed to particulate matter or bound in the sediment organic phase, they exhibit little potential for leaching or volatilization. They are highly stable in abiotic environmental media, with persistence typically measured in decades. An environmentally significant transformation process for dioxin congeners is believed to be photo-degradation of chemicals not bound to particles in the gaseous phase or at the soil-air or water-air interface.

Chemical degradation of dioxins and furans through reductive chlorination can also occur. Recent research in the San Jacinto estuary found widespread occurrence of known dioxin-degrading bacteria, *Dehalococcoides* spp., in sediments throughout the Houston Ship Channel and Galveston Bay. These bacteria use polychlorinated compounds as electron acceptors in the anaerobic process of de-halorespiration. Anaerobic, sulfate-reducing conditions and relatively high bulk organic carbon levels appear to be needed for enhanced microbial dioxin degradation.

Detailed Summary

Nationally, sediments are considered to be a sink for dioxins. Dioxins entering surface waters partition rapidly to particulates, and preferentially to the organic carbon fractions in suspended solids, and are then transported and/or deposited with bedded sediments. Black carbon (carbon-rich soot and soot-like material) is believed to offer more binding sites for organic materials but its relative abundance and composition is highly variable; it generally comprises less than 10 percent of the total organic carbon (TOC) pool in aquatic sediments. The presence of strong sorbing phases such as black carbon and other carbon matrices limit mobility and bioavailability of dioxins and furans and other organic compounds (e.g., PAHs).

The concentrations of freely dissolved concentrations of contaminants in surface waters and in the sediment biologically active zone, rather than bulk sediment concentrations, determine ecological effects and biological uptake. Contaminants in the near-surface, biologically active and/or physically mixed zone of the sediments, including sediments containing large proportions of pulp mill wastes, may move between solid and aqueous phases and be remobilized from the sediment bed by sediment resuspension and porewater to surface water exchange. Once in the water column, upstream or downstream contaminant transport can occur. Direct biological uptake can also occur from surface and suspended sediments, porewater and surface water. Partitioning between suspended solids and surface and porewater depends on the relative chemical concentrations, organic carbon levels and composition, and the dissolved surface water fraction, as well as reaction kinetics and the partitioning behavior of individual dioxin congeners. These factors are site and often sample-specific in the environment. For samples with very high dioxin levels (e.g., those from the waste impoundments), the sorption capacity of the sediments is exceeded, resulting in very high estimates of dissolved dioxins and furans (greater than 1 pg/L), whereas in most areas, the sediment sorption capacity is estimated to result in dissolved fractions less than 0.1 pg/L.

Tetrachlorinated dioxin and furan congeners may bioaccumulate in aquatic food webs and associated bird and mammal species; more recent literature confirms that other congeners have limited potential to bioaccumulate. The principal route of exposure is through the ingestion of contaminated food, as opposed to respiration across gill surfaces for fish or aquatic invertebrates. However, dioxins have been detected in waters, making them potentially available for biological uptake, even at very low concentrations. Certain benthic organisms accumulate dioxins from water at the water to sediment interface and through intake of phytoplankton, zooplankton, and suspended particulate materials that may contain higher concentrations of these chemicals than the surrounding water.

Fate and Transport Model

The mathematical modeling framework that was applied in the Site study consists of hydrodynamic, sediment transport, and chemical fate and transport models that are linked together (Figure 5-44). The hydrodynamic model accounts for the effects of the following factors on water movement in the San Jacinto River:

- Freshwater inflow from Lake Houston Dam
- Freshwater inflow from tributaries to the HSC that are upstream of its confluence with the San Jacinto River
- Tides.

However, a limitation of the sediment transport models that are currently used for simulating the transport of sediment in rivers, estuaries, and coastal seas is that they are not able to predict changes in channel widths due to bank erosion or predict changes in geometry due to meandering of a river or stream channel. Because the San Jacinto River, which is located in a coastal area exposed to hurricanes and other severe storms, is subject to these types of large scale sediment movements, as occurred during the 1994 storm, the ability of the model to access the Site under severe conditions is limited. A further limitation of the model is that the sediment transport model is decoupled from the hydrodynamic model, or in what is called the non-morphologic mode. This means is that predicted changes in bed elevations (and therefore water depths) in grid cells due to erosion or deposition are not accounted for in the hydrodynamic model. As a result, the flow is not adjusted to account for changes in water depths.

For the Site, the hydrodynamic model is used to simulate temporal and spatial changes in water depth, current velocity, and bed shear stress. This information is transferred from the hydrodynamic model to the sediment transport model, where it is used to simulate the erosion, deposition, and transport of sediment in the San Jacinto River. The sediment transport model is used to simulate temporal and spatial changes in suspended sediment concentrations in the water column and bed elevation changes (i.e., bed scour depth and net sedimentation rate). The results from the hydrodynamic and sediment transport models are transferred to the chemical fate and transport model, which calculates spatial and temporal variations of dioxin and furan concentrations in the water column and sediment bed of the Study Area, which was defined as the San Jacinto River from Lake Houston Dam to the confluence with the HSC.

The hydrodynamic, sediment transport, and chemical fate and transport models are constrained by governing equations that are based on the conservation of mass and momentum. Mechanistic formulations and algorithms based on the state of the science are used in these models to simulate the processes governing the movement of water, sediments, and chemicals. The formulations and algorithms used to simulate sediment deposition and erosion and chemical fate processes are based on empirical information and data from a wide range of laboratory and field studies. In addition, data collected from within the Study Area were used to determine the various parameters used in the models, which provides additional constraints on the models. A primary objective of all modeling studies is to use laboratory and site-specific data to constrain model inputs to the greatest extent possible because it reduces the uncertainty in model predictions and increases model reliability.

The spatial domain for the hydrodynamic model encompasses the San Jacinto River from Lake Houston Dam to the confluence with the HSC, and also includes a portion of the HSC (to ensure accurate representation of circulation within the Site area. The resolution of the grid cells is spatially variable, with high resolution (i.e., smaller grid cells) in the region near the northern impoundments. The sediment transport and chemical fate models use the same numerical grid as the hydrodynamic model. The hydrodynamic model was calibrated using current velocity and water surface elevation data collected at two locations in the Study Area during 2010 and 2011.

The calibration and validation results demonstrate that the model is able to simulate the hydrodynamics within the Study Area (i.e., San Jacinto River from Lake Houston Dam to the confluence with the HSC). The lack of high-flow conditions during the sampling period creates

potential impacts on model uncertainty. At smaller spatial scales the uncertainty in model reliability is higher; however, as the spatial scale increases, the uncertainty in model predictive capability decreases. This trend (i.e., decreasing uncertainty in model reliability with increasing spatial scale) is consistent with sediment transport models developed at other sites.

LAND USE

The land parcels closest to the Site are predominantly commercial/industrial, followed by residential areas. As you move further from the Site, the amount of residential land use increases, along with other land use categories not found in the immediate vicinity of the Site, such as undeveloped land, farms, parks, and lands listed as other (e.g., schools and hospitals). Generally development is more intense near the San Jacinto River and Houston Ship Channel to the south. Land uses upstream include residential, industrial, and municipal activities. The land use types in the area surrounding the Site are shown in [Figure 3-20](#).

Commercial and recreational fishing activity occurs throughout Galveston Bay. Within the Site area, fishing is known to occur, but the amount and frequency of fishing has not been determined. Consumption of molluscs and shellfish (clams, mussels, and oysters) taken from public fresh waters is prohibited by TDSHS. Within public salt waters, these shellfish may be taken only from waters approved by TDSHS. TDSHS shellfish harvest maps designate approved or conditionally approved harvest areas. Waters within the Site area are not included on these maps.

Although the lands within the Site area are private, points of access available to the public occur along and within the area and allow for a variety of recreational activities including picnicking, swimming, nature walks, bird watching, wading, fishing, boating, water sports, and other shoreline uses. In the area to the south of the I-10 Bridge on the west side of the river, children and adults have been reported to at times play along the shoreline, wade in the water, and fish.

GROUNDWATER AND SURFACE WATER USE

There are no surface water intakes within 15 miles downstream of the Site.

The shallow alluvium and the deeper sand zone below the Beaumont clay zone have no water wells within 0.5-miles of the Site.

There are three groundwater wells near the east bank of the San Jacinto River that are within approximately 3,000-feet of the Site ([Figure 2-6](#)). The Harris County WCID-1 (#6516506) well penetrates the Lower Chicot Aquifer at a depth of 537 feet (elevation -497 feet MSL) and is approximately 1,000 feet due east of the former impoundments. A well owned by C. Fitzgerald (#6516812) penetrates the Upper Chicot Aquifer at a depth of 125 feet (elevation -95 MSL) and is approximately 1,900 feet southeast of the former impoundments. A well owned by Vahlco Corp (#6516811) penetrates the Lower Chicot Aquifer at a depth of 530 feet and is approximately 3,500 feet south of the former impoundments. There are a number of other domestic and public supply wells completed in the Chicot Aquifer at greater distances from the Site. These wells are typically deeper than 200-feet, and in some cases deeper the 500-feet. A

map of all wells and borings of all types in the area is shown on **Figure JEFF**. This map includes all wells in the Texas Water Development Board and the Submitted Drillers Report databases.

HUMAN HEALTH RISK ASSESSMENT

Northern Impoundments

The human health risk assessment was prepared by Integral Consulting Inc. and Anchor QEA, LLC. (2013). Human health risks in the area of investigation north of I-10 (northern impoundments) were characterized for three hypothetical receptor groups: recreational fishers, subsistence fishers, and recreational visitors (see Tables... for exposure assumptions??). The exposure media evaluated were sediments in four individual beach areas, soils throughout the entire area of the northern impoundments and edible fish and shellfish (see Conceptual Site Model, **Figure 1-1 from BHHRA**). For each receptor group, the potential for long-term exposure to **COPCHS** was evaluated under baseline conditions (i.e., immediately prior to the **TCRA**). The evaluation was completed for a series of different hypothetical scenarios that address direct contact in different areas or ingestion of different types of tissue. Incremental risks from background, and reductions in risk resulting from completion of the TCRA, were also evaluated.

The parameters used for evaluating potential exposures and estimating risks and hazards relied on multiple conservative assumptions, which enhance the likelihood that potential assumed exposures and estimated risks are overestimated. The key findings of this **BHHRA** and conclusions about the potential health risks are summarized below.

*Insert some of the key methods stuff... (highlighting different than usual)
Basics on dioxin cancer hazard assmt, rather than old EPA cancer slope factor
Bioavailability... 0.5, rather than 100%*

Of the **COPCHS** identified for evaluation in this BHHRA for the area north of I-10 and the aquatic environment, dioxins and furans were identified as a risk driver in all media evaluated for the area north of I-10 and the aquatic environment. PCBs in fish and shellfish tissue, and methylmercury in catfish tissue were additionally identified as **COPCHS** that contributed substantially to potential risks associated with the area under study.

The results of this BHHRA generally indicate that hypothetical fishing and recreational exposure scenarios that assume direct contact with sediment within the original 1966 perimeter of the northern impoundments (i.e., termed “Beach Area E”) under baseline conditions (i.e., immediately prior to the TCRA) would result in higher potential exposures to risk driving **COPCHS**, than fishing and recreational scenarios elsewhere within the area under study.

To aid in the presentation of results in a manner useful for risk management, the results of the risk assessment are summarized in two sections below. First, the results for scenarios that assumed exposure to sediments at Beach Area E, together with consumption of fish or shellfish from the adjacent **FCA**, or soils from north of I-10 are summarized. Second, a summary of results for scenarios that assumed exposure to sediments at other areas (i.e., outside of the 1966

Detailed Summary

impoundment perimeter (termed "Beach Area A", "Beach Area B/C", and "Beach Area D") in combination with consumption of fish or shellfish from adjacent FCAs or soils is presented (see Figure from BHHRA...).

Hypothetical Scenarios with Exposure at Beach Area E

Three types of hypothetical receptors—recreational fishers, subsistence fishers, and recreational visitors with potential exposure to sediments at Beach Area E were evaluated. These scenarios assumed that recreational and subsistence fishers exposed via direct contact with beach sediments also ingested fish or shellfish from the adjacent FCA. Hypothetical recreational visitors who contacted sediments in this area were assumed to also contact soils throughout the study area.

Noncancer Hazards

RME noncancer HIs greater than 1 were estimated for hypothetical fishing and recreational scenarios that assume direct contact with sediments at Beach Area E (see Table... from BHHRA). For all three potential receptor groups, regardless of the other media to which they were exposed, assumed direct contact to sediments in Beach Area E accounted for over 98 percent of the RME hazard for reproductive/developmental endpoints.³¹ Although the HIs exceeded 1, these results do not necessarily indicate that adverse health effects would have occurred under baseline conditions. The CTE noncancer HIs for all potential receptors in this area were less than 1 (see Tables... from BHHRA).

The RME estimates relied on a number of highly conservative parameters, including the use of the maximum detected concentration of TEQ_{DF} as the EPC for estimating exposure. As a result, a substantial margin of safety was built into the RME estimates for the baseline condition. Completion of the TCRA construction in July, 2011 rendered sediments at Beach Area E inaccessible for direct contact by humans, and is also likely to have led to reductions in tissue concentrations in catfish and clams obtained from this area (although this cannot be confirmed with existing data), substantially reducing any baseline risks in this area.

Cancer Risks

All estimated excess cancer risks for potential recreational fishers, subsistence fishers, and recreational visitors who were assumed to contact COPCHS (other than dioxins and furans) in sediments and soils, and ingest fish or shellfish from the waters within USEPA's Preliminary Site Perimeter were within or below USEPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} (see Tables... from BHHRA).

Cancer Hazards

RME dioxin cancer HIs greater than 1 were estimated for all hypothetical fisher and recreational visitor scenarios that assumed direct contact to sediments at Beach Area E (see Table... from BHHRA). As was the case for noncancer hazards above, for these potential receptors assumed direct contact to sediment sediments in Beach Area E accounted for over 98 percent of the RME hazard. Although the cancer HIs exceeded 1, these results do not necessarily indicate that cancer

Detailed Summary

effects to the hypothetical fishers and recreational visitors would have occurred under baseline conditions. The CTE cancer HIs for all hypothetical receptors in this area were less than 1 (see Table... from BHHRA), and the RME estimates relied on a number of highly conservative parameters, including the use of the maximum detected concentration of TEQ_{DF} as the concentration term for estimating exposure. As a result, a substantial margin of safety was built into the RME estimates. Completion of the TCRA construction in July, 2011 rendered sediments at Beach Area E inaccessible for direct contact by humans, substantially reducing any baseline risks in this area.

Scenarios with Exposure at Beach Areas A, B/C, and D

Three types of potential receptors with exposure to sediments at Beach Areas A, B/C, and D were evaluated. Hypothetical recreational and subsistence fishers exposed via direct contact with sediments at one of the defined beach areas were assumed to also ingest fish or shellfish from the adjacent FCA. Recreational visitors who contact sediments in one of the defined beach areas were assumed to also contact soils throughout the area under study.

Noncancer Hazards

This analysis indicated that no adverse noncancer health effects would be expected for hypothetical recreational visitors and recreational fishers as a result of contact with COPCHS in sediments at Beaches A, B/C, or D and soil throughout USEPA's Preliminary Site Perimeter, and consumption of fish or shellfish from the adjacent FCA. RME noncancer HIs for all COPCHS combined for hypothetical recreational fishers were below 1 (see Tables... from BHHRA). For hypothetical recreational fishers, RME HIs grouped by toxicity endpoint, were all below 1 (see Tables... from BHHRA).

Noncancer HIs greater than 1 occurred only for the hypothetical subsistence fisher under the following scenarios: direct contact to sediments at Beach Area A in combination with ingestion of catfish from the adjacent FCA 2/3; direct contact to sediments at Beach B/C in combination with consumption of either catfish from the adjacent FCA 2/3 or clams from the adjacent FCA 2; and direct contact to sediments at Beach D in combination with consumption of catfish from FCA 1 (see Tables... from BHHRA).

For each of these scenarios the predominant pathway of estimated exposure was the consumption of tissue; direct contact with sediments accounted for less than 5 percent of exposure. Potential risk driving COPCHS in tissue were dioxins and furans and PCBs in catfish and clams, and methylmercury in catfish.

Although the noncancer HIs exceeded 1 in these scenarios, these results do not indicate that adverse health effects would have occurred in the hypothetical receptor group under baseline conditions. The RME estimates relied on a number of highly conservative parameters including upper bound consumption rates, the assumption that an individual would obtain 100 percent of the fish or shellfish consumed from the area under study over the entire assumed exposure duration, and the assumption that the concentration of lipophilic compounds would not be reduced through preparation or cooking.

Detailed Summary

As indicated by the PRA completed for this BHHRA, the influence of variability in estimated consumption rates and the portion of an individual's total consumption obtained from the area under study have large impacts on estimated exposures and resulting hazards for the hypothetical fisher population.

Cancer Risks

All estimated excess cancer risks for scenarios that assumed exposures to Beach Areas A, B/C, and D were within or below USEPA's target cancer risk range of 1×10^{-6} to 1×10^{-4} . These included both RME and CTE cancer risks for the hypothetical recreational fisher, subsistence fisher and recreational visitor scenarios (see Tables... from BHHRA).

Cancer Hazards

It is not expected that dioxin-related cancer effects would have occurred under the baseline hypothetical recreational visitor and recreational fisher scenarios as a result of assumed contact with dioxins and furans in sediments at Beach Area A, B/C, or D and soil, and consumption of fish or shellfish from within USEPA's Preliminary Site Perimeter. RME cancer TEQ_{DF} HIs for these potential receptor groups were all below 1 (see Tables... from BHHRA).

RME dioxin cancer HIs greater than 1 were limited to the hypothetical subsistence fisher receptor group under the following assumed scenarios: direct contact with sediments at Beach Area A in combination with ingestion of catfish from the adjacent FCA 2/3; direct contact with sediments at Beach Area B/C in combination with consumption of catfish from the adjacent FCA 2/3; and direct contact with sediments at Beach D in combination with consumption of catfish from FCA 1 (see Tables... from BHHRA).

For each of these hypothetical scenarios, consumption of tissue accounted for 95 percent or more of estimated COPC_H exposure. Although the cancer HIs exceeded 1, these results do not indicate that cancer effects would have occurred in the hypothetical receptor group under baseline conditions. The RME estimates relied on a number of highly conservative parameters including upper-bound consumption rates, the assumption that an individual obtains 100 percent of the fish or shellfish consumed over the entire exposure duration from waters within USEPA's Preliminary Site Perimeter, and the assumption that concentrations of lipophilic compounds are not reduced during preparation or cooking.

Incremental Hazard

Exposure media that contributed the most to estimated human exposure to COPC_Hs included sediments at Beach Area E, catfish fillet at FCA 2/3 and FCA 1, and clams from FCA 2. However, risk-driving COPC_Hs present in catfish were also present at elevated concentrations in catfish harvested from background areas designated for this risk assessment. For example, in catfish fillet, 41 to 42 percent of the baseline hazard attributed to TEQ_{DF} exposures and 55 to 60 percent of baseline hazard associated with PCBs were also present under background conditions, suggesting that background conditions with respect to these COPC_Hs contributed roughly one-half of the total potential risks under relevant scenarios. In addition, the hazards associated with

Detailed Summary

background exposure to methylmercury in catfish fillets were similar to or higher, indicating that any exposures from the study area are not contributing additional risks due to methylmercury.

Baseline Versus Post-TCRA Hazards

[as discussed in Appendix F]... Post-TCRA noncancer TEQ_{DF} HIs for the hypothetical recreational fisher and recreational visitor scenarios are less than 1. For the hypothetical subsistence fisher, the exposure scenarios that assumed consumption of catfish in combination with direct contact to sediment (Scenarios 1A, 2A, and 3A) have post-TCRA RME TEQ_{DF} noncancer HIs of 6. These are lower than the baseline HIs, which ranged from 9 to 100, and higher than the background HIs of 4.

Post-TCRA cancer TEQ_{DF} HIs are less than 1 for all of the hypothetical recreational fisher and recreational visitor scenarios evaluated. Only the post-TCRA exposure scenarios for the hypothetical subsistence fisher that assumed consumption of catfish in combination with direct contact with sediment result in an RME cancer TEQ_{DF} HI of greater than 1 (HI=2). These are lower than baseline cancer TEQ_{DF} HIs, which ranged from 3 to 40, and only slightly higher than the background cancer TEQ_{DF} HIs of 1 for those scenarios.

The greatest hazard and risk reductions resulting from the TCRA are for baseline scenarios that assumed direct exposure to Beach Area E (Scenarios 3A, 3B, and 3C). This was because the majority of estimated TEQ_{DF} exposure and hazard for these scenarios was related to direct contact rather than to the ingestion of fish or shellfish, and because potential exposure to sediment in this area was completely restricted once the TCRA was implemented. For these scenarios, the hazard reductions resulting from TCRA implementation range from 84 to 100 percent. For hypothetical exposure scenarios that assumed direct contact with sediments at Beach Area A, B/C, or D and consumption of catfish or clam from the adjacent FCA, the hazard reductions resulting from the TCRA implementation range from 65 to 86 percent.

The post-TCRA evaluation indicated that the TCRA implementation has substantially reduced potential baseline risks for the area under study. Noncancer and cancer hazards calculated for the hypothetical recreational fisher and recreational visitor scenarios are all below the target HI of 1 under post-TCRA conditions. While potential noncancer and cancer hazards calculated for the hypothetical subsistence fisher scenario under post-TCRA conditions exceed the target HI of 1, these HIs exceed background levels only by factors of 2 or less.

ECOLOGICAL RISK ASSESSMENT

REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

Remedial Action Objectives (**RAOs**) address specific exposure pathways and receptors, and provide the basis for defining PRGs. The RAOs for the Site are based on results of the Baseline Human Health Risk Assessment (**BHHRA**) and Baseline Ecological Risk Assessment (**BERA**). The RAOs were developed to be consistent with reasonably anticipated future uses and applicable to the areas north and south of I-10 for which remedial alternatives were developed. The RAOs for the Site are as follows:

- **RAO 1:** Eliminate loading of dioxins and furans from the former paper mill waste impoundments north and south of I-10, to sediments and surface waters of the San Jacinto River.
- **RAO 2:** Reduce human exposures to paper mill waste-derived dioxins and furans from consumption of fish and shellfish by remediating sediments affected by paper mill wastes to appropriate cleanup levels.
- **RAO 3:** Reduce human exposures to paper mill waste-derived dioxins and furans from direct contact with intertidal sediment by remediating sediments affected by paper mill wastes to appropriate cleanup levels.
- **RAO 4:** Reduce human exposures to paper mill waste-derived dioxins and furans from direct contact with upland soils to appropriate cleanup levels.
- **RAO 5:** Reduce exposures of fish, shellfish, reptiles, birds, and mammals to paper mill waste-derived dioxins and furans by remediating sediment affected by paper mill wastes to appropriate cleanup levels.
- **RAO 6:** Prevent human exposure to ground water contaminants at concentrations above the **MCL** in the Southern Impoundment.

The PRGs considered all potential exposure pathways associated with hypothetical receptor exposure scenarios including reasonably anticipated future uses of specific areas within the Site area, and all COCs for each medium. Based on consideration of reasonable potential future uses within the Site area, four PRGs were developed for sediments and soils. The reasonable potential future users within the Site area used in the development of alternatives include hypothetical recreational fisher and hypothetical recreational visitor for sediments, and hypothetical construction and hypothetical commercial workers for soils.

All of the PRGs are based on $TEQ_{DF,M}$ concentrations that are protective of human health, based on the Reasonable Maximum Exposure (RME) scenario for the subject hypothetical receptors.

The $TEQ_{DF,M}$ PRG for sediment outside the footprint of the northern waste pits is based on exposure to dioxins and furans by a hypothetical recreational visitor, as evaluated in the BHHRA. For a noncancer hazard quotient equal to 1, the $TEQ_{DF,M}$ concentration in sediment for this PRG is **220 nanograms per kilogram (ng/kg)**. Although the PRG for the hypothetical recreational fisher would also be appropriate, the PRG for the hypothetical recreational visitor is more conservative.

Detailed Summary

The PRG for soil/sediment within the footprint of the northern waste pits is based on the reasonable future use of this area, which is industrial or commercial. For a hypothetical future outdoor commercial worker exposed to soil/sediment in the northern waste pits footprint, and for a noncancer hazard quotient equal to 1, the PRG as a $TEQ_{DF,M}$ concentration in soil/sediment is **1,300 ng/kg**.

There are no risks to ecological receptors from dioxins and furans in the area of investigation south of I-10. The only risks associated with the dioxins and furans in the area of investigation south of I-10 was for a hypothetical future construction worker who might, in three discrete locations, come into contact with the dioxins and furans within the upper 10 feet of soil. The PRG for protective of a hypothetical future construction worker for $TEQ_{DF,M}$ was calculated to be **450 ng/kg**, and is applicable to the average concentration in a soil column of 10 feet.

DESCRIPTION OF ALTERNATIVES

Remedial alternatives were developed using various applications of the following general response actions for the areas north and south of I-10. The general response actions include the following:

- Institutional Controls: ICs are administrative measures that are implemented to mitigate risks or to protect the integrity of engineered controls. ICs include “Proprietary Controls,” which are restrictions placed on the use of private property, “Governmental Controls,” which include restrictions on the use of public resources, “Enforcement Tools” that may be imposed by an agency to compel certain actions, and “Informational Devices,” which include notices about the presence of contamination or fishing advisories.
- Monitored Natural Recovery: Generally, MNR has advantages of low implementation cost and is non-invasive. However, MNR has limitations in that it can be slow in reducing risks and it leaves contaminants in place where there are risks that buried contaminants can be re-exposed or dispersed if the sediment bed is significantly disturbed by natural or man-made forces. MNR would entail periodic sampling and an analytical program that would be implemented to monitor the progress of natural recovery. Sampling would be conducted at a representative range of locations and at appropriate time intervals to allow trends in concentrations to be assessed. The scope of the MNR sampling and analysis, and any adaptive management actions that could be taken as a result of the MNR assessment, would be determined during remedial design.
- Treatment: Treatment alternatives considered in the Feasibility Study (FS) include S/S of soils and sediments with a reagent such as portland cement. S/S was successfully performed during the TCRA on a portion of the western cell materials. For costing purposes, the FS assumes a treatment reagent and dosage concentration similar to that which was used during the TCRA, or 7 to 8 percent by weight portland cement. To accomplish S/S, physical removal of the existing cap materials, as well as the overlying surface waters will be required prior to mixing the reagent. The treatment areas in the Eastern Cell that are normally inundated would need to be surrounded by a sheetpile wall, and the water drawn down prior to initiating S/S. The sheetpile system used would need to be robust to withstand differential water levels inside and outside the treatment cell. Sheetpile walls may be overwhelmed

Detailed Summary

during significant storm and flood events in the river. In these circumstances, releases of wastes that are exposed as a result of construction activities could occur. Finally, given the physical constraints of the Site, an off-site materials management facility is anticipated to be necessary for temporary stockpiling of cap materials, treatment reagents, and associated machinery to implement the S/S.

- Containment: Containment by an armored cap would be designed, monitored, and maintained in accordance with USACE and USEPA capping guidance. In addition, the specific recommendations by USACE to enhance the cap are incorporated into any alternative that includes capping as an element. The OMM plan for the cap would include periodic monitoring and monitoring following key storm events to identify the need for possible cap maintenance, followed by appropriate repair activities. Cap protection from future barge or other vessel operations in the cap area would be assessed and detailed during the remedial design phase. For purposes of cost development in the FS, a conceptual submerged perimeter rock berm has been included as a protective perimeter barrier for the alternatives that include a permanent cap to further ensure the long-term protectiveness of the cap by reducing potential for vessel impacts. Finally, given the physical constraints of the Site, an off-site staging area is anticipated to be necessary for temporary stockpiling of cap materials, similar to that which was utilized during construction of the TCRA.
- Removal: Sediment removal by dredging or excavation has been the most frequent cleanup method used by the Superfund program at sediment sites. Dredging or excavation has been selected as the cleanup method at more than 100 Superfund sites. At approximately fifteen to twenty percent of these sites, an in-situ cleanup method, either capping or MNR, was also selected for sediment at part of the site. The San Jacinto River Waste Pits Site alternatives that involve full or partial removal of the cap and excavation of impacted material from beneath the cap and in other locations all involve dredging. Dredging projects typically result in some degree of sediment resuspension, release, and residuals. The use of operational and engineering controls (rigid and flexible barriers) would be included to the extent practicable to mitigate these potential releases. Dredging residuals would be managed by backfilling the dredge footprint, or by placement of a clean sediment cover or engineered cap over the dredge footprint. Backfill and capping would be used to manage residuals for removal-based alternatives that do not achieve the PRGs, and a nominal 6-inch-thick cover of clean sediment would be used to manage dredging residuals for removal-based alternatives that achieve the PRG. An off-site materials management facility will be required for material staging, stabilization and processing for bulk transportation to an off-site landfill.

For the southern impoundment, the upland excavations would be accomplished with conventional earthwork equipment (excavators, dozers, loaders, etc.). Considerations related to upland excavations include maintaining stable sidewalls, and managing water for those excavations that must be performed below the groundwater table. To maintain stable sidewalls, the excavation may be sloped to a stable angle of repose if space permits, or shoring could be used. Earthwork safety guidelines generally require any excavation deeper than 5-feet to have sloped or shored sidewalls. Excavation water controls could include ditches and sumps, well point systems, or deep wells. The dewatering effluent may need to be treated prior to disposal or shipped to licensed facility depending on the quality of the

Detailed Summary

water. The selection of appropriate dewatering technology and decisions about dewatering effluent treatment are remedial design elements.

Best Management Practices (BMPs) will be applied to the dredging operations. BMPs can be successful in mitigating potential resuspension and release under normal flow conditions. However, BMPs could be overwhelmed during significant storm and flood events. For alternatives 4N, 5N, 5aN, and 6N, which require removal of the TCRA cap during construction, the consequences of flooding could be significant as the exposed and disturbed materials would be at risk of spreading beyond the remedial area.

- **Disposal:** It was initially unclear whether there were landfill facilities that would accept dredged or excavated material from the Site. Subsequently, two landfill facilities were tentatively identified that indicated materials from the SJRWP Site could potentially be disposed of at these locations without incineration. Thus, further consideration of incineration as a component of disposal has been screened out. Given the limited upland space available adjacent to the TCRA Site, an off-site facility with water access would be necessary to unload barges and process dredged sediment prior to shipment to the landfill. The off-site facility would need to accommodate stockpiles for armor rock and dredged material, and would need space to accommodate a sediment drying process (conceptually envisioned to be mixing in a drying reagent for this FS Report). An off-site materials management facility will be required for material staging, stabilization and processing for bulk transportation to an off-site landfill, and would also need to accommodate any water treatment and disposal determined to be necessary during remedial design. Finally, the off-site facility would need access to regional transportation infrastructure such as heavy-duty roads or rail.

Area North of I-10

All of the alternatives for the area north of I-10, except Alternative 1N (No Further Action) and Alternative 5aN, include MNR for the river sediment area adjacent to the Upland Sand Separation Area located west of the northern impoundments. This area was used to process material previously dredged northwest of the Site and is already isolated from potential receptors by several feet of sediment with $TEQ_{DF,M}$ concentrations below the PRG. However, the river sediment area adjacent to the Upland Sand Separation Area is in a barge operations area and is subject to propeller wash by the tug boats moving the barges. Monitoring of sediment conditions in this area would be performed to confirm that deposition of clean sediment was continuing. The remedial action alternatives for the area north of I-10 include:

- **Alternative 1N** – TCRA Cap, and Ongoing Operations, Monitoring, and Maintenance (No Further Action).

Estimated Total Cost: \$0.52 million (net present value)

Construction Time Needed to Implement Remedy: 0 months

This alternative assumes the TCRA cap would remain in place, together with fencing, warning signs and access restrictions established as part of the removal, and would be subject to ongoing OMM. This estimate includes the cost of TCRA cap design and construction and

Detailed Summary

USEPA 5-year reviews; these same costs are included in the estimate for each of the other alternatives for the area north of I-10.

The only sediment samples outside of the limits of the TCRA cap with $TEQ_{DF,M}$ concentrations exceeding the PRG for hypothetical recreational visitors are two subsurface sediment samples collected north of I-10 from one location (Figure 2-4) near the Sand Separation Area. These samples are buried beneath at least 3 feet of sediment with $TEQ_{DF,M}$ concentrations below the PRG. Alternative 1N includes no provisions for this Upland Sand Separation area.

- **Alternative 2N** – TCRA cap, ICs and Monitored Natural Recovery MNR.

Estimated Total Cost: \$10.3 million (net present value)

Construction Time Needed to Implement Remedy: 0 months

This alternative includes the actions described under Alternative 1N (TCRA cap and ongoing OMM), ICs in the form of deed restrictions and notices, and periodic monitoring to assess the effectiveness of sediment natural recovery processes in the Sand Separation Area.

Monitoring of sediment conditions in this area would be performed to confirm that deposition of new sediment was continuing to maintain surface $TEQ_{DF,M}$ concentrations below the PRG for hypothetical recreational visitors. The MNR plan would include methods for assessing whether deposition or erosion were occurring at monitoring stations between monitoring events. The actual scope and timeline of monitoring would be determined during the remedial design and during implementation of the monitoring program over the years.

ICs would be used to:

- Alert property owners of the presence of subsurface materials exceeding PRGs;
- Describe the need for protective equipment and training if excavation of subsurface materials exceeding PRGs is required in the northern impoundment footprint;
- Describe requirements for the management of any excavated soil or sediment exceeding PRGs;
- Describe the need to restore the TCRA cap following any disturbance;
- Establish limitations on dredging and anchoring within the footprint of the TCRA cap by requesting, in accordance with 33 CFR 165.5, that the U.S. Coast Guard District Commander establish a regulated navigation area.

- **Alternative 3N** – Permanent Cap, ICs and MNR.

Estimated Total Cost: \$12.5 million (net present value)

Construction Time Needed to Implement Remedy: 2 months

This alternative includes the actions described under Alternative 2N plus additional enhancements to the TCRA cap. This alternative will increase the long-term stability of the TCRA cap consistent with permanent isolation of impacted materials and meet or exceed USACE design standards. Additional enhancements will include adding additional armor

Detailed Summary

rock to the cap, which will further flatten the slopes, and measures to construct a protective perimeter barrier to protect the permanent cap from vessel traffic. The permanent cap would be designed to be protective under a 500 year flood event. The alternative includes, in concept, the construction of a submerged rock berm as the protective perimeter barrier. Cap monitoring, inspections and maintenance, as needed, would be incorporated into the final remedy to ensure the long-term effectiveness of the remedy. The permanent cap will use rock sized for the “No Displacement” design scenario, which is more conservative than the “Minor Displacement” scenario used in the TCRA cap’s design. The armor rock that will be used to create the permanent cap will meet or exceed sediment cap design guidance and the recommendations made by **USACE** in its review of the TCRA design and construction. An off-site staging area may be required for management of rock armor materials, similar to that which was utilized during the removal construction. Alternative 3N is estimated to require the 260 truck trips during construction.

ICs would be implemented as described for Alternative 2N, and MNR would address the affected sediment near the Sand Separation Area, which is already isolated from potential receptors by several feet of sediment with $TEQ_{DF,M}$ concentrations below the PRG and would be further isolated by deposition of additional clean sediment.

Water quality impacts from turbidity associated with placing the new armor rock are also low for this alternative because the armor rock fines that would create the turbidity would be from the rock acquired for the project and therefore not be chemically impacted. Further, risks of impacts due to storm events during construction are considered negligible because implementation does not require removing the existing TCRA cap to complete the work, and there are no rigid barriers that could restrict flow during potential flood events.

- **Alternative 4N** – Partial Solidification/Stabilization, Permanent Cap, ICs and MNR.

Estimated Total Cost: \$23.2 million (net present value)

Construction Time Needed to Implement Remedy: 17 months

This alternative includes the actions described under Alternative 3N; however, about 23 percent of the TCRA cap (2.6 acres above the water surface and 1.0 acre in submerged areas) would be removed and about 52,000 cubic yards (cy) of materials with $TEQ_{DF,M}$ that exceeds a concentration 13,000 nanograms per kilogram (ng/kg), would undergo solidification and stabilization (S/S). After the S/S is completed, the Permanent Cap would be re-constructed and the same ICs and MNR as in Alternatives 2N and 3N would be implemented. An off-site staging area may be required for management of rock armor materials, stabilization reagents and associated treatment equipment.

- **Alternative 5N** – Partial Removal, Permanent Cap, ICs and MNR.

Estimated Total Cost: \$38.1 million (net present value)

Construction Time Needed to Implement Remedy: 13 months

This alternative includes partial removal of the TCRA cap and the same 52,000 cy of material that would undergo S/S under Alternative 4N would instead be excavated for off-

Detailed Summary

site disposal. After the removal was completed, the Permanent Cap would be re-constructed and the same ICs and MNR that are part of Alternatives 2N to 4N would be implemented. An off-site materials management facility will be required for material staging, stabilization and processing for bulk transportation to an off-site landfill.

- **Alternative 5aN** - Partial Removal of Materials Exceeding the PRG, Permanent Cap, ICs and MNR.

Estimated Total Cost: \$77.9 million (net present value)

Construction Time Needed to Implement Remedy: 19 months

All material beneath the TCRA cap in any location where the water depth is 10-feet or less and which has a $TEQ_{DF,M}$ at or above the PRG for sediment of 220 ng/kg, about 137,600 cy, would be excavated for off-site disposal. To implement this alternative, about 11.3 acres (72 percent) of the TCRA cap would be removed to allow for this material to be dredged. This alternative includes an engineered barrier to manage water quality during construction. In shallow water areas (water depths up to approximately 3 feet), this barrier would be constructed as an earthen berm. In areas with water depths deeper than about 3 feet, the berm would transition into a sheetpile barrier around the work area. Following removal of impacted sediment, the area from which sediments are removed would be covered with a residuals management layer of clean cover material, and the remaining areas of the cap would be enhanced, and the same ICs and MNR that are part of the preceding four alternatives would be implemented. An off-site materials management facility will be required for material staging, stabilization and processing for bulk transportation to an off-site landfill.

- **Alternative 6N** – Full Removal of Materials Exceeding the PRG, ICs and MNR.

Estimated Total Cost: \$99.2 million (net present value)

Construction Time Needed to Implement Remedy: 16 months

All material above the PRG of 220 ng/kg located beneath the TCRA cap or at depth in an area to the west would be removed. This would involve removal of the existing TCRA cap in its entirety and the removal of 200,100 cy of material. The dredged area would then be covered with a layer of clean fill. An off-site materials management facility will be required for material staging, stabilization and processing for bulk transportation to an off-site landfill.

Area South of I-10

All of the alternatives for the Southern Impoundment, except the no action alternative, include a Technical Impracticability Waiver and deed restrictions restricting use of the shallow alluvial ground water. The remedial action alternatives for the area south of I-10 include:

- **Alternative 1S** – No Action.

Estimated Total Cost: \$140,000 (net present value)

Construction Time Needed to Implement Remedy: 0 months

Detailed Summary

This alternative only includes five-year reviews, but no remediation actions of any kind would be implemented.

- **Alternative 2S** – ICs.

Estimated Total Cost: \$270,000 (net present value)

Construction Time Needed to Implement Remedy: 0 months

This alternative includes deed restrictions applied to parcels in which the $TEQ_{DF,M}$ exceeds the PRG within the upper 10-feet.

- **Alternative 3S** – Enhanced ICs.

Estimated Total Cost: \$660,000 (net present value)

Construction Time Needed to Implement Remedy: 1 month

This alternative would incorporate the ICs identified in Alternative 2S and add physical features to enhance the effectiveness of the ICs. The physical features would include bollards to define the areal extent of the remedial action areas at the surface and a marker layer that would alert workers digging in the area that deeper soil may be impacted.

- **Alternative 4S** – Removal and Off-site Disposal.

Estimated Total Cost: \$9.9 million (net present value)

Construction Time Needed to Implement Remedy: 7 months

This alternative includes the removal of impacted soil from the surface to a depth of 10-feet. The removed volume is estimated to be 50,000 cy. Soil removal below the existing building (an elevated frame structure) and a concrete slab in the area would not be done and deed restrictions would be applied to this area where the $TEQ_{DF,M}$ exceeds the PRG within the upper 10-feet.

COMPARATIVE ANALYSIS OF ALTERNATIVES

Nine criteria are used to evaluate the different remediation alternatives individually and against each other in order to select a remedy. The nine evaluation criteria are (1) overall protection of human health and the environment; (2) compliance with Applicable Relevant and Appropriate Requirements (**ARARs**); (3) long-term effectiveness and permanence; (4) reduction of toxicity, mobility, or volume of contaminants through treatment; (5) short-term effectiveness; (6) implementability; (7) cost; (8) State/support agency acceptance; and (9) community acceptance. This section profiles the relative performance of each alternative against the nine criteria, noting how it compares to the other options under consideration.

After the remedial alternatives that have passed the preliminary screening step have been individually assessed against the NCP remedy evaluation criteria in the detailed screening step, a

Detailed Summary

comparative analysis is conducted to evaluate the relative performance of the alternatives with respect to each of the criteria. **Tables 5.2 and 5.2** summarize the information presented below.

Overall Protection of Human Health and the Environment

Overall protection addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.

For the area north of I-10, all of the remedial alternatives evaluated satisfy the threshold criteria of protecting human health and the environment.

For the area south of I-10, other than Alternative 1S, the remedial alternatives meet the protectiveness threshold criteria. The pockets of subsurface soil with $TEQ_{DF,M}$ concentrations exceeding the hypothetical future construction worker PRG in the area south of I-10 are isolated from the surface by several feet of clean soil. $TEQ_{DF,M}$ concentrations for specific sample intervals are shown in **Figure 2-5**. Potential exposure to soil exceeding the PRG in this area is limited to circumstances involving excavation into the affected depth zone or potential contact with excavated soil if it were to be left at the surface. The hypothetical future construction worker PRG is based on exposure to soil from 0- to 10-feet below the surface. Average $TEQ_{DF,M}$ concentrations in the 0- to 10-foot interval are shown in **Figure 3-5**. Alternative 1S, the no action alternative, does not address the risk associated with the future construction worker exposure scenario, and therefore does not provide protection of human health and the environment, is not an acceptable alternative, and will not be evaluated further.

Compliance with Applicable Relevant and Appropriate Requirements

Section 121(d) of CERCLA, 42 U.S.C. § 9621(d), and NCP § 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as ARARs, unless such ARARs are waived under CERCLA section 121(d)(4), 42 U.S.C. § 9621(d)(4).

For the area north of I-10, all of the remedial alternatives evaluated satisfy the threshold criteria of addressing ARARs.

For the area south of I-10, other than Alternative 1S and Alternative 4S, the remedial alternatives are in compliance with ARARs. With reasonable care, the other remedial alternatives can be implemented in compliance with ARARs. Soil that is removed (Alternative 4S) would be transported in compliance with Department of Transportation standards and permanently managed in a permitted landfill cleared by the USEPA's regional off-site rule contact. BMPs would be implemented to control dust, stormwater, and potential releases of impacted soil.

The **TCEQ** has determined that the shallow alluvial ground water in the Southern Impoundment area is a Class 2 aquifer, or a potential drinking water source. [add Discussion & TI discussion]

Long-Term Effectiveness and Permanence

Long term effectiveness and permanence refers to expected residual risk and the ability to maintain reliable protection over time, once cleanup levels have been met.

For the area north of I-10, the long-term effectiveness evaluation of MNR-based remedies projects that the SWAC $TEQ_{DF,M}$ will decrease by approximately a factor of two in a 10- to 15-year time frame within the Site area due to natural sedimentation processes in the river.

However, with MNR the contaminated sediment will remain in place and could be exposed and/or dispersed by severe flooding in the San Jacinto River, or by the operation of tug boats in the river sediment area adjacent to the Upland Sand Separation Area. Therefor MNR is judged to have less long-term effectiveness than the capping or the removal alternatives.

Construction of the TCRA cap reduced SWAC $TEQ_{DF,M}$ within the Site area by approximately 80 percent, and natural recovery will continue to reduce SWAC $TEQ_{DF,M}$ because of the ongoing input of sediment with low $TEQ_{DF,M}$ concentrations from upstream sources. All of the alternatives would benefit from the natural deposition of additional sediment resulting in the decline of $TEQ_{DF,M}$ concentrations in surface sediment.

Alternative 1N does not include ICs and MNR, nor is the TCRA cap upgraded, so the long-term effectiveness of this alternative ranks lower than that for all of the other alternatives. The long-term effectiveness of Alternative 2N is primarily derived from the TCRA cap and the ICs that would protect the integrity of the cap. Long-term effectiveness is also provided by the layers of surface soil and sediments with concentrations below PRGs and the monitoring that would confirm the continued deposition of clean sediment isolating the affected sediment outside of the footprint of the TCRA cap. Long-term simulations conducted with the fate and transport model indicate the surface sediment concentrations averaged over the area of the Site are predicted to decline by a factor of 2 over an approximate 10- to 15-year time period; monitoring would be conducted to verify actual reductions in sediment concentrations. The highest $TEQ_{DF,M}$ concentrations within the area of the Site, in the footprint of the TCRA cap, are already isolated from potential receptors by the cap.

The existing cap is not further enhanced in Alternatives 1N or 2N compared to Alternative 3N, and Alternative 3N would therefor provide a greater level of long-term effectiveness than either Alternative 1N or 2N. In addition, there could be an increased need for future long-term monitoring and maintenance under Alternatives 1N and 2N than for Alternative 3N.

The long-term effectiveness of the existing Armored Cap in Alternative 3N is enhanced by adding armor rock to the cap and flattening the slopes of the cap compared to Alternatives 1N and 2N. Flattening the slopes to create the permanent cap, as shown in [Figure 4-1](#), would further enhance the structural integrity and long-term reliability of the cap. Surface flow and wave break modeling was performed to evaluate potential erosive forces associated with a variety of storms and extreme flow events. The results of the modeling were used to confirm that the rock selected for the cap would further resist movement and provide enhanced long-term containment of material beneath the permanent cap compared to Alternatives 1N and 2N.

Detailed Summary

However, the sediment transport models that are currently used today for simulating the transport of sediment in rivers, estuaries, and coastal seas are not able to predict changes in channel widths due to bank erosion or predict changes in geometry due to meandering of a river or stream channel. Because the San Jacinto River, which is located in a coastal area exposed to hurricanes and other severe storms, is subject to these types of large scale movements of sediments, as occurred during the 1994 storm, the potential exists for cap failure and contaminant release due to large scale river geometry changes (i.e., sediment erosion around and below the cap). Therefore all of the containment alternatives have less long-term effectiveness than the alternatives that remove part or all of the contaminated material.

Alternative 4N would increase the shear strength of soils and sediments through treatment, which would further increase their stability and long term effectiveness beyond that provided by the TCRA cap.

Alternatives 4N, 5N, 5aN, and 6N have greater long-term effectiveness than the other alternatives because the paper-mill waste is either treated (partial stabilization treatment, Alternative 4N) or removed (partial, Alternatives 5N and 5aN; or full, Alternative 6N). Removing the waste material will reduce the long term operation and maintenance costs as well as greatly reducing the potential impacts from a catastrophic storm in the future.

Alternatives 4N, 5N, 5aN, and 6N all involve varying amounts of removal of the existing TCRA cap to access the paper-mill waste. These actions will all create releases of varying amounts of waste material to the river through re-suspension of the sediment during the dredging operation. Modeled releases during construction indicate that the surface sediment concentration within the Site area for these alternatives will increase in the first year from xx ng/kg for the no further action case to between yy ng/kg and zz ng/kg. After 21-years, the modeled dioxin level in sediment for all alternatives decreased to between aa ng/kg and bb ng/kg. To put these concentrations in perspective, the dioxin levels in the first year following remediation reach a level that about 90% less than the PRG for sediment, or less. Further, the dioxin levels in sediment are modeled to have a half-life of about 10-years, meaning that the levels would be about 50% lower after 10-years. An assessment of the risk for the worst case alternative, which is Alternative 6N (full removal), indicates that the risk of toxicity from the re-suspension of sediment would have a hazard quotient (HQ) of XXX, which is significantly less than the HQ of 1.

For the area north of I-10, Alternatives 5aN and 6N have the greatest long term effectiveness because both alternatives involve the removal of most of the contaminated material, which would then not be exposed to future severe erosion events. The removal will greatly reduce the potential long-term impacts from any catastrophic storm and will reduce the expenses for any future cap repairs. Both of these alternatives will result in the release of additional contaminated material due to re-suspension caused by dredging, but the risks associated with this are well below the protective risk range.

For the area south of I-10, soil with $TEQ_{DF, M}$ concentrations exceeding the PRG is isolated from the surface by clean overburden. The only route of potential exposure is through excavation into the impacted depth interval. The physical markers (Alternative 3S) would draw attention to the ICs and enhance their effectiveness. Alternative 4S would achieve long-term effectiveness by

Detailed Summary

permanently removing the impacted soil from the 0- to 10-foot depth interval from the Site and securely disposing of the soil in a permitted landfill. While the ICs, particularly with the addition of physical markers (Alternative 3S), would provide reliable long-term protection, they rely on the integrity of future construction workers to comply with the restrictions. Therefore, complete removal of the impacted soil in the depth interval of potential excavation (Alternative 4S) may provide a somewhat higher level of long-term effectiveness because it is not subject to inappropriate future use of the area.

Reduction of Toxicity, Mobility, or Volume (TMV) of Contaminants Through Treatment

Reduction of toxicity, mobility, or volume of contaminants through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

For the area north of I-10, Alternatives 1N and 2N do not include additional measures to reduce TMV. However, a portion of the soils in the Western Cell were previously solidified during the TCRA construction as shown in **Figures 4-1**. Thus, these alternatives are comparable in reduction of TMV. Alternative 3N further reduces potential mobility within the TCRA Site by increasing the protection of the armored slopes, and thus ranks more favorably than Alternatives 1N and 2N. Alternatives 4N and 5N take additional measures through S/S (Alternative 4N) or removal (Alternative 5N) of approximately 52,000 cy of sediments and soils, and are comparatively better than Alternative 3N for reduction of TMV, but subject to possible issues related to re-suspension of materials during remedy implementation. Alternative 5aN removes approximately 137,600 cy of sediment, and thus compares more favorably for reduction of TMV than Alternatives 4N and 5N, but subject again to possible issues related to re-suspension of materials during remedy implementation. **However, the toxicity from re-suspension of sediment during dredging are well below the Hazard Quotient of 1 meaning that no adverse health effects are expected.** Alternative 6N has the greatest volume of removal, 200,100 cy, however, this is counterbalanced by potentially significant dredge water column and re-suspension releases greater than Alternative 5aN. For the area north of I-10, Alternatives 5aN and 6N have the greatest long term effectiveness because both alternatives involve the removal of most of the contaminated material.

For the area south of I-10, Alternatives 2S and 3S do not include any treatment of impacted soil. Alternative 4S would include some treatment of excavated soil, as needed to eliminate free liquids for transportation and disposal. The treatment may involve amendment of the soil with Portland cement, which would reduce the potential mobility of COCs. Water removed from the excavation would be treated, if necessary, to reduce toxicity prior to discharge.

Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during implementation.

For the area north of I-10, Alternatives 1N and 2N do not entail any construction, and thus have no short-term impacts.

Detailed Summary

In-situ capping will be less disruptive of the local community than dredging or excavation. Short-term risks to the community, ecological receptors, or workers associated with the implementation of Alternative 3N are limited to minimal turbidity associated with placement of armor rock, potential accidents during construction of the permanent cap, air emissions from construction equipment, and truck traffic in the community. Because of the limited duration of construction for Alternative 3N (2 months), these risks are considered to be low compared to Alternatives 4N through 6N. There are other significant sources of air emissions and traffic in the region, including the industrial activities that occur adjacent to the Site, and the presence of I-10. Alternative 3N does not significantly disturb the TCRA cap or require handling of sediments, so re-suspension of sediment is not significant compared to the other Alternatives 4N through 6N. Further, risks of impacts due to storm events during construction, which could be significant for Alternatives 4N through 6N, are considered negligible for Alternative 3N because implementation does not require removing the existing TCRA cap to complete the work.

Alternatives 4N, 5N, 5aN, and 6N will all result in re-suspension of impacted sediments due to removal of part or all of the TCRA cap. Alternatives 5aN and 6N would have the greatest re-suspension of sediments because most or all of the TRRC cap and underlying waste material would be removed. This re-suspended sediment may potentially result in increased fish tissue concentrations, at least initially following the dredging operations. However, the toxicity from re-suspension of sediment during dredging is well below the Hazard Quotient of 1 meaning that no adverse health effects are expected. Alternatives 4N, 5N, 5aN, and 6N are less sustainable alternatives considering potential ozone precursor, PM and greenhouse gas emissions from the construction activity, and will result in more community impact from traffic and the potential for accidents and off-site spills. These alternatives are expected to require a relatively large off-site facility for management of materials and related activities (armor rock and dredged sediment stockpiling, sediment dewatering, transloading, and off-site shipping), which could be difficult to obtain.

Because of their longer durations, Alternatives 4N through 6N also have a higher likelihood that a high-water event during construction could overtop the perimeter water quality control features, which would exacerbate short-term impacts because the TCRA cap needs to be removed to accomplish the work. Compared to Alternatives 4N, 5N, 5aN, and 6N, which have significantly longer durations, Alternative 3N ranks significantly more favorably for short-term effectiveness.

BMPs will be applied to the dredging operations. BMPs can be successful in mitigating potential re-suspension and release under normal flow conditions. However, BMPs could be overwhelmed during significant storm and flood events. For Alternatives 4N, 5N, 5aN, and 6N, which all require some amount of removal of the TCRA cap during construction, the consequences of flooding could be significant as the exposed and disturbed materials would be at risk of spreading beyond the remedial area. As a reference point, modeling indicates that a 5-year return event storm would have a maximum water level increase of 4.9-feet. The probability of this occurring increases with the length of time required for construction. For example, there would be an 11% chance of a 5-year return event storm occurring in a 6-months period, but for an 18-month period the probability increases to 28%. However, this risk can be mitigated to some extent by performing the remediation in sub-sections as opposed to a one-time removal of the cap area required for remediation. For the area north of I-10, Alternatives 1N, 2N, and 3N

Detailed Summary

have the greatest short term effectiveness because these alternatives do not involve the removal of any of the TCRA cap.

For the area south of I-10, Alternative 2S does not entail any construction, and thus has no short-term impacts. Excavations (Alternative 3S and 4S) would require BMPs to control dust and stormwater. Short-term impacts associated with Alternative 3S would be minimal given the shallow depth of excavation, limited volume of material that would be moved, and absence of significant concentrations of COCs in the shallow soil. Alternative 4S would require exposing soil with TEQ_{DF,M} concentrations exceeding the PRG, which introduces the potential for exposure to COCs through direct contact with the soil, inhalation or ingestion of impacted dust, and contact with impacted soil suspended in runoff. The volume of soil and the duration of the project would also be greater than for Alternative 3S, and Alternative 4S would require off-site transportation of the soil to a disposal facility, increasing the potential for exposure to COCs, emissions of greenhouse gasses, nitrogen oxides (NO_x), and particulate matter (PM), and tracking of COCs off-site. Therefore, Alternative 4S has the least short term effectiveness. The use of appropriate personal protective equipment (PPE) and proper management of excavated soil, the potential risks posed by the impacted soil can be reliably and effectively managed

In summary, Alternatives 2S and 3S would not require exposing impacted soil or transporting material off-site and would be simpler to implement. Excavation of impacted soil (Alternative 4S) would introduce short-term risks of exposure on-site and potentially off-site in the event of a release en route to the disposal facility.

Implementability

Implementability considers the technical and administrative feasibility of a remedy such as relative availability of goods and services and coordination with other governmental entities.

For the area north of I-10, Alternatives 1N and 2N do not have any implementability issues because they do not entail construction. Both are more favorable from an implementability standpoint compared to Alternatives 3N, 4N, 5N, 5aN, and 6N. Alternative 3N is a short-duration project that entails proven technology (i.e., the same activities were demonstrated during construction of the TCRA cap) that can be deployed with readily-available materials and local, experienced contractors.

Implementability concerns, such as restrictions on equipment size and availability of off-site staging area properties are substantially greater for Alternatives 4N, 5N, 5aN, and 6N compared to Alternative 3N because of the much larger scope and scale of these alternatives. Identifying and securing an off-site staging area is considered an even greater challenge for Alternatives 5N, 5aN, and 6N compared to Alternative 4N because dredged sediment would need to be managed at the off-site staging area, which requires a larger footprint, and given the nature of the dredged material, might make finding a willing landowner difficult. Proper management of cap material and excavated wastes, and on-site processing and management for dredged sediments for off-site transportation to neighboring roadways, will be critical for effective implementation of Alternatives 5N, 5aN, and 6N. Finding a suitable off-site facility for Alternatives 5N, 5aN, and 6N is considered a more significant implementability challenge than Alternative 4N because the former alternatives will manage dredged sediments at the facility. Compared to Alternative 5N,

Detailed Summary

this issue is magnified for Alternatives 5aN and 6N because of the significantly greater volume of material that must be handled at the off-site facility. Based on these factors, Alternative 3N is less favorable than Alternatives 1N and 2N, but more favorable than the remaining alternatives for the area north of I-10 in terms of implementability.

Alternative 4N requires the removal of the TCRA cap, which is considered a technical challenge, and requires S/S to be completed for an area of sediments that is typically submerged and would need to be dewatered, which is considered another technical challenge. Engineering controls for Alternative 4N may not be adequate to prevent the release of sediments to the surrounding environment and may be difficult to install; this would be especially true during potential high flow events that could occur during construction. Alternative 4N is considered to be unfavorable for implementability compared to Alternative 3N.

Alternatives 5N, 5aN, and 6N also require removal of the TCRA cap (as noted above, a technical challenge), and management of a significant volume of sediment and soil for off-site disposal. Similar to Alternative 4N, engineering controls may not be adequate to prevent the release of sediments to the surrounding environment, and for Alternative 5aN would be difficult to install; this would be especially true during potential high flow: for Alternatives 4N through 6N there is a 30 to 40 percent chance that a high water event could occur during construction resulting in overtopping of the engineering controls. Thus, all of these alternatives are considered equally as unfavorable as Alternative 4N for implementability. For the area north of I-10, Alternatives 1N, 2N, and 3N have the least implementability issues because these alternatives do not involve the removal of any of the TCRA cap.

For the area south of I-10, there are no significant implementability concerns associated with Alternatives 2S and 3S. None of the alternatives requires specialized equipment, techniques, or personnel. Coordination with property owners would be required to establish ICs and for access to the project work site. Alternative 4S would involve more physical activity for implementation, including off-site transportation of impacted soil, but the operations are routine for remedial actions. The additional and significant implementability concerns are the increased truck traffic on Market Street and the potential for flooding while impacted soil is exposed during implementation of Alternative 4S. Provisions may need to be made to handle the additional volume of traffic. The duration of the excavation should not exceed 7 months and implementation could be timed for periods when high water is least likely.

Cost

Cost includes estimated capital and operation and maintenance costs as well as present worth costs. Present worth cost is the total cost of an alternative over time in terms of today's dollar value. A discount rate of 7% was used for calculation of the net present value costs. Cost estimates are expected to be accurate within a range of +50 to -30 percent.

For the area north of I-10, **Table 5-1** includes a summary of estimated costs for each alternative. Costs range from lowest to highest in order from Alternative 1N to Alternative 6N: Alternative 1N is estimated to cost \$9.5 million; Alternative 2N is estimated to cost \$10.3 million; Alternatives 3N and 4N differ by a factor of almost 2, with estimated costs of \$12.5 and \$23.2 million, respectively; Alternative 5N is estimated to cost \$38.1 million; Alternative 5aN is

Detailed Summary

estimated to cost \$77.9 million; and Alternative 6N is estimated to cost \$99.2 million. Estimated costs include development and operation of the off-site staging area. However, because the exact location and configuration of the off-site staging area are beyond the scope of this FS these elements may not be fully reflected in the FS estimated durations or costs.

The capital costs for Alternative 3N are primarily associated with the construction of the permanent cap, including development and operation of the off-site staging area. However, because the exact location and configuration of the off-site staging area is unknown at this time, the off-site staging area may not be fully reflected in the estimated durations or costs. The costs of preparing sampling plans, deed restrictions and notices, and a soil management plan are the same as those for Alternative 2N. The long-term costs are for monitoring and maintenance of the permanent cap, collecting and analyzing environmental samples, evaluating the data, and preparing reports to document MNR.

The costs of Alternatives 4N, 5N, 5aN, and 6N are significantly higher than for Alternatives 1N, 2N, and 3N. However, Alternatives 4N through 6N provide additional long-term protectiveness that will reduce any potential impact from a future large scale storm compared to the other alternatives.

For the area south of I-10, **Table 5-1** includes a summary of estimated costs for each alternative. Costs range from lowest to highest in order from Alternative 1S to Alternative 4S. Alternative 1S (No Action) is estimated to cost \$140,000, Alternative 2S (ICs) is estimated to cost \$270,000, Alternative 3S (Enhanced ICs) is estimated to cost \$660,000, and Alternative 4S is estimated to cost \$9.9 million.

PRINCIPLE THREAT WASTE

The National Contingency Plan (**NCP**) establishes an expectation that remedies will use treatment to address the principal threats posed by a site wherever practicable. The “principal threat” concept is applied to the characterization of “source materials” at a Superfund site. The NCP also establishes an expectation that remedies will use engineering controls for wastes that pose a relatively low long-term threat.

Principle threat materials (**PTM**) are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained and/or would present a significant risk to human health or the environment if exposure were to occur. Identification of PTM is made on a site-specific basis and is intended to help streamline and focus the remedy selection process.

According to “Rules of Thumb for Superfund Remedy Selection” (EPA 540-R-97-013, August 1997), *“Although no “threshold level” of risk has been established to identify principal threat waste, a general rule of thumb is to consider as a principal threat those source materials with toxicity and mobility characteristics that combine to pose a potential risk several orders of magnitude greater than the risk level that is acceptable for the current or reasonably anticipated future land use, given realistic exposure scenarios.”* The earlier “A Guide to Principle Threat and Low Level Threat Wastes” (9380.3-06FS, November 1991), states *“No “threshold level” of toxicity/risk has been established to equate to “principal threat.” However, where toxicity and mobility of source material combine to pose a potential risk of 10^{-3} or greater, generally*

Detailed Summary

treatment alternatives should be evaluated.” The 10^{-3} risk level is one order of magnitude higher than the protective risk range for carcinogens of 10^{-4} to 10^{-6} .

The dioxin containing paper-mill waste material at the Site is considered a principal threat waste because of the serious consequences should a release occur. The remediation technologies considered for the Site include containment, S/S, and removal. Because the Site is located in a river environment that has experienced a number of hurricanes and other severe storms over the years, with catastrophic results, the removal of most of the contaminated material will provide better long term protectiveness compared to the other remediation technologies.

PREFERRED ALTERNATIVE

The preferred alternative for the northern impoundment area is a modified Alternative 5aN and the preferred alternative for the southern impoundment area is a modified Alternative 4S.

A modified Alternative 5aN is the preferred alternative to address the area north of I-10, including the northern impoundments. This alternative includes both removal and capping. This alternative is shown in **Figure XX**. This alternative includes the following specific components:

- Soil/sediment in the northern impoundments footprint where the water depth is approximately 10 feet or less and with $TEQ_{DF,M}$ concentrations exceeding PRG (220 ng/kg), plus soils that exceed 13,000 ng/kg $TEQ_{DF,M}$ in any water depth, would be removed. The actual extent of the removal will be determined based on a Value Engineering evaluation of the sheet pile location prepared during the Remedial Design.
- The soil/sediment would then be dewatered and transported to a permitted landfill for disposal.
- This alternative requires partial removal of the TCRA cap.
- Soil/sediment removal would be performed behind an engineered barrier, including a berm in shallow water areas and a sheetpile in deeper water areas.
- Following removal of the soil/sediment, a 6-inch thick residuals cover would be placed over the area.
- Permanent Cap enhancements would be constructed in the northern impoundments footprint where the PCL is exceeded but the water is deeper than 10-feet. The actual extent of the cap enhancements will be determined based on a Value Engineering evaluation of the sheet pile location prepared during the Remedial Design. The cap enhancements include adding additional armor rock to the cap, which will further flatten the slopes, and construction of a perimeter submerged rock barrier to protect the Permanent Cap from vessel traffic.
- The Permanent Cap will be designed to be protective under a 500 year flood event, and meet or exceed USACE and USEPA cap design criteria.
- Alternative 5aN would be modified by including the removal of the affected sediment near the Upland Sand Separation Area as described under Alternative 6. Following removal of the sediment, a 6-inch thick residuals cover would be placed over the area.

A modified Alternative 4S is the preferred alternative to address the southern impoundment area. This alternative is shown in **Figure 4-11**. This alternative includes the following specific components:

Detailed Summary

- Excavation and replacement of soil in three areas.
- Soil would be removed to a depth of 10-feet below grade.
- Dewatering is required to allow excavation of the impacted soil.
- Effluent from dewatering may require treatment prior to disposal.
- Following further dewatering of the excavated soil as necessary, the soil will be transported for disposal at a permitted landfill.
- The excavation will be backfilled with clean soil and re-vegetated.
- Pavement on market Street adjacent to Remedial Action Area South-1 would be repaired.
- Alternative 4S would be modified so that no removal would be performed in the area of the existing building and concrete slab within Remedial Action Area South-3. Further, ICs would be placed to address the area below the building and concrete slab where the $TEQ_{DF,M}$ exceeds the PRG within the upper 10-feet.

The implementation of Alternative 5aN for the area north of I-10 and Alternative 4S for the area south of I-10 will result in the best long term effectiveness and permanence for the Site because most of the contaminated material will be removed from this Site which is subject to severe flooding and erosion. In addition, it will yield the least uncertainty about future environmental exposure to and transport of contaminated sediment resulting from in-stability of the in-situ cap.

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Applicable or relevant and appropriate requirements (ARARs) relating to the various remedial alternatives are discussed below and listed in Table 3-1.

For the area north of I-10:

- **Alternative 1N** would not result in construction impacts or other changes to baseline conditions that would trigger any action-, chemical-, or location-specific ARARs. Because no construction activity is included in this alternative, there are no substantive permit conditions that would need to be met.
- **Alternative 2N** would involve a minimal amount of physical activity for the implementation of ICs (e.g., landowner notifications; restrictions on dredging and anchoring) and ongoing implementation of existing engineering controls. For the same reasons presented in the ARAR compliance discussion under Alternative 1N, due to the minimal amount of active construction involved, Alternative 2N is also expected to generally meet the substantive requirements of the ARARs.
- **Alternative 3N** would involve the placement of fill material (the additional armor rock) into the San Jacinto River to create the permanent cap. The placement of fill would trigger compliance with Clean Water Act (CWA) Section 404(b) (1) and potentially other ARARs related to surface water quality standards. However, Alternative 3N is expected to generally meet the substantive requirements of the ARARs in Table 3-1 through implementation of the best management practices (BMPs). Construction of the Permanent Cap would require the placement of approximately 3,400 cy of additional cap armor rock material. Hydrodynamic modeling was performed to confirm that the placement of the additional armor rock would

Detailed Summary

not significantly affect flood-storage capacity in the San Jacinto River. Based on the results of this modeling, the long-term change to the maximum water surface elevation following placement of the additional armor rock under this alternative is estimated to be -0.01 to -0.02 feet, which is an indication that the effect of rock placement is negligible and immeasurable within the predictive capability of the flood model.

- **Alternative 4N** would trigger additional compliance requirements beyond those required for Alternative 3N due to the removal and replacement of the existing TCRA cap, as well as the implementation of the S/S treatment. The removal and replacement of cap material would trigger compliance with CWA Section 404(b)(1) and other ARARs related to surface water quality standards. The S/S may result in a 20 percent increase in the volume of the sediment in the area of treatment because of bulking due to the addition of the stabilization amendment. Application of the S/S to approximately 52,000 cy of sediment is estimated to result in 60,000 to 65,000 cy of amended sediment. This increase in volume could trigger a need to review potential flood storage impacts with Federal Emergency Management Agency (FEMA) and Harris County. Based on preliminary hydrodynamic modeling, the long-term change to the maximum water surface elevation following stabilization under this alternative is estimated to be 0.01 feet, which is an indication that the effect of S/S is negligible and cannot be quantified within the predictive capability of the flood model. It is anticipated that Alternative 4N, through implementation of the BMPs, would generally meet the substantive requirements of the ARARs in Table 3-1.
- **Alternative 5N** would include the removal of portions of the existing cap, removal of underlying soil/sediment, and transportation of sediment to an upland disposal facility. The removal of the TCRA cap and placement of rock for permanent cap construction would trigger compliance with CWA Section 404(b)(1) and along with the dredging action would trigger other ARARs related to surface water quality standards. Should Alternative 5N be identified as the remedy, additional evaluations would be conducted to determine the potential habitat impacts related to the construction of the Permanent Cap, dredging, and backfill. The removal of sediment would require the construction of an off-site material handling facility near the work area to offload barges, manage waste, stockpile and dewater sediment, and load these materials onto trucks or rail cars for off-site disposal. The construction and operation of the material handling facility will require substantial compliance with relevant permit requirements. Although land for the material handling facility may not be available within the USEPA's Preliminary Site Perimeter, the NCP (40 CFR 300.430(e)) defines on-site for this purpose as "the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action." Construction of the permanent cap would require the placement of approximately 3,400 cy of additional cap armor rock material. Hydrodynamic modeling was performed to confirm that the placement of the additional armor rock would not significantly affect flood-storage capacity in the San Jacinto River. Based on the results of this modeling, the long-term change to the maximum water surface elevation following placement of the additional armor rock under this alternative is estimated to be -0.01 to -0.02 feet, which is an indication that the effect of rock placement is negligible and immeasurable within the predictive capability of the flood model. Alternative 5N would be expected, through implementation of the BMPs, to generally meet the substantive requirements of the ARARs in Table 3-1.

- **Alternative 5aN** would generally trigger the same compliance requirements as Alternative 5N. If Alternative 5aN is identified as the preferred alternative, additional evaluations would need to be conducted to determine the potential habitat impacts related to impacts of dredging and placement of clean residual layer management materials to document compliance with CWA Section 404(b)(1) and other natural resource based ARARs. Removal of sediments and placement of a residuals cover would result in a net lowering of the mudline in the work area. Hydrodynamic modeling was performed to evaluate the effect of this change on flood-storage capacity in the San Jacinto River. Based on the results of this modeling, the long-term change to the maximum water surface elevation following dredging and residuals management placement is estimated to be -0.04 to -0.05 feet, which may not be measurable using the predictive capability of the flood model. Alternative 5N would be expected, through implementation of the BMPs, to generally meet the substantive requirements of the ARARs in Table 3-1.
- **Alternative 6N** would generally trigger the same compliance requirements as Alternatives 5N and 5aN. If Alternative 6N is identified as the preferred alternative, additional evaluations would need to be conducted to determine the potential habitat impacts related to impacts of dredging and placement of clean residual layer management materials to document compliance with CWA Section 404(b)(1) and other natural-resource based ARARs. Removal of sediments and placement of a residuals cover would result in a net lowering of the mudline in the work area. Hydrodynamic modeling was performed to evaluate the effect of this change on flood-storage capacity in the San Jacinto River. Based on the results of this modeling, the long-term change to the maximum water surface elevation following dredging and residuals management placement is estimated to be -0.04 to -0.05 feet, which may not be measurable within the predictive capability of the flood model. Alternative 5N would be expected, through implementation of the BMPs, to generally meet the substantive requirements of the ARARs in Table 3-1.

For the area south of I-10:

- **Alternative 1S** would not result in construction impacts or other changes to baseline conditions that would trigger any action-, chemical-, or location-specific ARARs identified in Table 3-1.
- **Alternative 2S** would not involve activities that would trigger ARARs. Therefore, no compliance issues are anticipated for this remedial alternative.
- **Alternative 3S** would involve limited excavation and stockpiling of shallow soil to place the marker layer and bollards. Construction activities would comply with ARARs, including the control of dust and stormwater.
- **Alternative 4S** would require compliance with ARARs related to dust emissions, stormwater controls, and disposal. Appropriate stormwater and air-quality controls would be used to protect air and water quality. Equipment leaving the work site would be decontaminated as needed to prevent tracking impacted soil on public roads, and each load of soil would be tracked to confirm that the material was received by the designated disposal facility.

TECHNICAL AND POLICY ISSUES

COST INFORMATION

Cost summary information for the remedial alternatives are presented in Table 1. Unit cost information is included in Table 3, and Tables 4 through 10 (FS App C) contain the cost estimates for the individual alternatives. Costs were developed using “*A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*” (USEPA 2000). This was supplemented with professional judgment where appropriate in estimating daily costs and production rates. Professional judgment drew on the recently completed Time Critical Removal Action, as well as other construction projects in the region.

A discount rate of 7% was used to calculate the net present value costs.

Costs for the remedial action alternatives range from \$9.5 to over \$99 million. Alternatives 1N and 2N have similar costs, primarily related to long-term OMM of the Armored Cap. Alternative 3N has a higher cost than Alternatives 1N and 2N as it also includes construction of the cap upgrades and a protective barrier to improve the long-term integrity of the cap.

Costs for Alternatives 4N, 5N, 5aN, and 6N are significantly higher than for Alternatives 1N, 2N, and 3N. This reflects the challenges of establishing and operating an off-site staging and processing area, removal of sections of the Armored Cap, in-situ treatment or excavation, and associated engineering controls, the quantity of materials being addressed, the duration of work, and the cost of transportation and disposal of impacted sediments.

LETTERS FROM STAKEHOLDERS AND STATE